Appendix

B

BIGHORN NATIONAL FOREST

Land and Resource Management Plan - DEIS

Appendix B Description of the Analysis

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Appendix B

Framework of the Planning Process

The revision of a forest plan is guided by the general planning process described in 36 CFR 219.12. This section discusses ten steps which led from the completion of the 1985 Forest Plan to the completion of a Revised Forest Plan.

Step 10 – Monitoring and Evaluation (Step 10 of the initial planning process)

The last step of the initial forest plan process is the first step in revising a forest plan. Annual monitoring and evaluation has been done since the forest plan was released in 1985. The monitoring reports have helped the Forest Supervisor identify several reasons to revise the forest plan.

Step 1 – Identifying the Purpose and Need

A series of six public meetings were held in November 2000 through January 2001 to ask the public to identify issues in the forest plan that needed revision. Local government officials, and state and federal agencies, were also involved at this stage. The feedback was screened into five possible categories of action:

1. Topics that required forest plan revision.
2. Other revision items that would not require a significant amendment but need to be addressed in the Revised Plan.
3. Topics related to plan implementation.
4. Topics outside the scope of a plan revision.

As a result of this scoping, five major revision topics for the forest plan revision were finalized:

- Biological and habitat diversity
- Roadless/Wilderness
- Timber suitability and Management of Forested Lands
- Recreation and Travel management
- Special Areas

As the planning process continued, other changes not specifically related to the five major topics were also considered. However, the revision topics have become the primary focus of the forest plan revision effort.

Step 2 – Planning Criteria

During this step, the remainder of the process is outlined. As the revised plan was being prepared, several mid-course corrections were necessary, as models were not available or working properly, computer resources or assistance was not available, or public suggestions added additional considerations. Throughout this process, the Bighorn National Forest used the 1982 version of the 36 CFR 219 planning regulations.

Step 3 – Inventory Data and Information Collection

A Geographic Information System (GIS) was used to build the database used in the plan revision. The type of data and information needed for the revision process was based on the revision topics, on what resources were available for data collection, and upon what data was available. The data was collected and assembled in a manner meaningful for addressing planning problems, as discussed later in this appendix.

Step 4 – Analysis of Management Situation (AMS)

This step determines the ability of the planning area to supply goods and services in response to society's demands. It provides background information for formulating a broad range of reasonable alternatives. The AMS focused on the revision topics and several of the models described in this appendix were initially developed during this step. Most of 2001 was devoted to compiling the Forest-wide and Geographic Area Assessments. The AMS was largely developed from the 1985 AMS, from the information and data collected and synthesized during the ASQ amendment process, and from the 2001 assessments.

Step 5 – Formulation of Alternatives

In late 2001, the steering committee was asked if they would like to participate in the development of alternatives. They chose not to, because they believed they did not have the technical expertise to do that. The steering committee preferred that the ID team draft alternatives and then provide comments on those. About this time, the "citizen's alternative" was presented.

An initial set of three alternatives was formulated by the interdisciplinary team following NEPA procedures. These three alternatives defined the extreme 'bounds' between commodity production and roadless/wilderness protection, with the existing Forest Plan in between. These alternatives were not well received when presented to the steering committee in July 2002. These alternatives were modified and three new alternatives were developed throughout the later part of 2002. In January 2003, six public meetings were held in the Bighorn area. The public was brought up to date on the revision process, and

was asked to review and comment on the alternatives. After a Regional Forester review in February 2003, the alternatives were set for the main effects analysis.

Throughout the remainder of 2003, the steering committee and the public were informed about various analyses and outputs. In December 2003, the steering committee was provided with an "Initial Effects Analysis", which summarized most of the effects of the alternatives. During January and Februrary, 2004, five days of steering committee meetings were held to review and improve the draft direction, the alternatives and the desired condition. Effects analysis modifications were made to incorporate these changes, and the set of alternatives that appear in the Draft Revised Plan was approved by the Regional Forester in March, 2004.

Step 6 – Estimated Effects of Alternatives

The physical, biological, economic, and social effects of implementing each alternative considered in detail were estimated and compared according to NEPA procedures. The level of accuracy of these estimates vary by resource area and analysis topic. This is due to, among other things:

- Forest Planning is a "coarse filter" approximation of the effects of a multitude of individual projects that will be conducted over the upcoming 10-15 year period. Individual project level planning will be a much finer resolution and accuracy.
- Data (including individual species occurrences, stand-level tree data, habitat conditions, etc.) at the 1.1 million acre scale is not as precise as the data that will be collected for individual projects.
- The resolution of mapping is inherently coarse at the Forest scale compared to project level planning. An example of this is the size of the existing Medicine Wheel National Historic Landmark. The establishment record sets the size as 110 acres, while the 1:100,000 scale Forest Plan management area map shows a NHL of 61 acres.

Step 7 – Evaluation of Alternatives

Significant physical, biological, economic, and social effects of implementing alternatives were evaluated. The steering committee was especially effective in conveying to the Forest Supervisor and ID team the social and economic implications of National Forest management, and the dependency the local communities have on the Bighorn NF.

Step 8 – Preferred Alternative Recommendation

The steering committee spent February 6, 2004 evaluating the alternatives. Evaluation criteria were the five revision issues, and how well the alternatives addressed items such as the County Land Use Plans and the Healthy Forest Restoration Act. At the end of the day, the state and local government cooperators and the Forest Leadership team provided the Forest Supervisor with input on which should be the preferred alternative. Each person also answered the question "What would you like the Regional Forester to know when

selecting a preferred alternative". The Regional Forester selected Alternative D as the preferred alternative, which is presented in the DEIS.

Step 9 – Plan Approval and Implementation

After receiving public comments on the DEIS, changes will be made to the Plan and EIS. There has been much public and steering committee concern over whether or not there will be "adequate time" for review and input into the final decision. The Forest will make every effort during the 90-day public comment period, and then over the subsequent development period, to provide opportunities for input. Recent Region 2 Forest Planning experience has been that substantive changes are made between draft and final, and we expect that to be the case. The Regional Forester will review the documents, make a final decision, and select an alternative as the Revised Forest Plan. This decision is expected in the spring of 2005.

Inventory Data and Information Collection

A Geographic Information System (GIS) was used to develop the forest plan revision database. The resulting database was used to analyze suitable timber lands, build the forest planning model (Woodstock/Stanley) analysis areas, and perform other analyses for the revision. To develop the database the following layers were overlaid in GIS:

- Integrated Resources Inventory (IRI) system – this layer contain physical, administrative, and vegetation data. These layers were initially handed off to the Forest in May 1999 and are further described in the Bighorn National Forest IRI Users Guide. The data has subsequently been updated as needed. The IRI data base includes three units:
    - The Common Land Unit represents relatively stable, terrestrial environment and is based on the integration of four components: geology, landform, soil and potential natural vegetation.
    - The Common Water Unit (CWU) contains basic watershed and water resource data.
    - The Common Vegetation Unit (CVU) contains existing vegetation data, generally homogenous in dominant life form, species composition, percent crown cover, size, vertical structure, and crown condition.
- Management area prescription by alternative – these layers contain the management area prescriptions allocated for each alternative. There is one layer for each alternative. The information in this layer is shown on the management area prescription maps accompanying this document.
- Inventoried roadless areas – this layer contains the agency inventoried roadless areas on the Forest. (FSH 1909.12 Chapter 7)
- Recreation areas and cultural sites – this layer contains developed recreation sites, such as picnic grounds, campgrounds, summer home sites, and ski areas. The layer also

contains the areas that are known to be highly sensitive to cultural resources over large areas.

- There are many other layers in the Forest data base, including, but not limited to: roads and trails, past activities, improvements such as fences and pipelines, land ownership, topographic and hydrologic features, administrative boundaries, etc.

Timber Suitability Analysis

Process to Determine Timber Suitability

Requirements to perform analysis of timber suitability are found in 36 CFR 219.14, 36 CFR 219.28, and FSH 2409.13, chapter 20. The "Region 2 – Process to Determine Timber Suitability and Standards for Display" was the procedure used with minor variations based on local factors.

Tentatively Suitable Timberlands Analysis is described in the "Region II Desk Guide for Forest Planning". The documentation of the process begins on page G.2 and the chapter is dated July 12, 2001. Major headings in this document represent the steps defined on pages G.8 and G.9. Additional documentation was drawn from the 1991 Environmental Assessment titled, "Amendment to Restocking Standards, Bighorn National Forest Land and Resource Management Plan" Rocky Mountain Region, R2, hereafter referred to as the "Restocking EA".

The processes outlined below were begun using ArcInfo 7.X on an IBM AIX (Unix) server. The documentation in the Restocking EA was forced to match the acreage listed in the official ownership records for the National Forest System. This acreage does not necessarily match the summarization of the sites listed in the RIS database and the RIS data summary does not match the calculation of area for the GIS coverage of RIS sites. Aside from these three sources, the Forest has also switched from the RIS data system to the Integrated Resource Inventory coverages. This document will attempt to report the results from each of these systems so that the reader can interpret the source of the changes in reported acreage.

A. **EA Acres** - These acreages match what was reported in the Restocking EA and are adjusted to sum up to the official acreage reported in "Land Areas of the National Forest System" published by the USDA Forest Service. In this system, each section of land is measured as 640 acres and partial sections are based on the "aliquot part" of a section.

B. **ORA-RIS** – Each RIS site has an acreage that was calculated by using a Planimeter to measure the acreage of the mapped site. For a number of reasons, the oracle acres do not match the EA Acres.

C. **GIS-RIS** – the ArcInfo Geographic Information System calculates these acres. These numbers do not match Oracle or EA Acres but they use the same calculation method as the IRI statistics. 273 sites, totaling 8888 acres in the RIS coverage, do not have labels that can be linked to Oracle. There is a known error whereby the labels from the RIS map do not match the labels in the RIS table. These acreages are not included in category B or C statistics.

D. **IRI** – The Integrated Resource Inventory is an entirely new, complete inventory of the Forest, based on photo interpretation of 1992 aerial photos. IRI calculations include Common Vegetation Unit (CVU) data for vegetation, Common Land Unit (CLU) data for soils, Digital Elevation Model (DEM) data for elevation, slope, and aspect, Automated Lands Project (ALP) line work for ownership and withdrawn lands. These various sources are integrated through GIS operations.

1. National Forest System (NFS) Lands

Identification of National Forest System lands is accomplished with the identification of the proclaimed boundary and identification of other land ownerships within the proclaimed boundary. Most of the Forest's primary Geographic Information System (GIS) coverages (or data layers) can be found on the Forest's computer system in the "GIS library". *The library filing space in this document will refer to files that are stored within: J:\fsfiles\ref\library\gis\forest\bighorn.* The coverage for proclaimed boundary and ownership is filed under the "admin" directory with the coverage name of "status".

The status coverage is made up of an Arc Info architecture called "regions". Regions are very powerful, but they can be hard to work with. The first step in the capability analysis is to "dissolve" the regions so that we end up with a simpler, polygon, coverage represented by the codes FS and NON-FS. This work resulted in a temporary coverage called "t-suit-1". Specific command documentation is in the file "ownership.aml".

Land Category	EA Acres	ORA-RIS	GIS-RIS	IRI
Proclaimed National Forest	1115162	1122847	1111236	1112474
- Unlinked or No Data sites			- 8888	
- Other Ownership & Unknown	- 7491	- 7055	- 7079	- 7459
Net National Forest Ownership	1107671	1111961	1095269	1105015

2. Non-Forested Cover Types

"Subtract non-forested cover types" … The Bighorn National Forest developed the "Key to Identification of Capable, Available, and Suitable Forested Land" in response to a Forest Plan Lawsuit. This process equates to steps numbered 1 to 3 in that key: "Water", (steps 1 and 2), "Site is developed for non-forest use" (step 3).

Water may be classified as "census water", timber component 001; or "non-census water", timber component 100. These two assignments use GIS library data from the physical/cwu directory in a coverage called "p_hydro". An Arc Macro Language (AML) file called "t-suit-water" is used to measure the size of the water body and make the timber component assignments.

The primary source for cover type information is the Common Vegetation Unit coverage.

That coverage is located in the GIS library under the flora/cvu directory in a coverage called cvu. Data to support the cvu coverage is in the "IDS" tables in our Oracle data. The Oracle data is stored in "normalized" tables that can be very difficult to connect and use. A useable summary of the data is in the "ids_cvu_calcs" table in Oracle. A copy of this table is stored as an INFO table with the name cvu.ids_calcs. This naming convention causes the table to be exported any time the cvu coverage is exported. However, caution must be applied so that the INFO table is updated whenever Oracle data changes.

To accomplish this task I copied the CVU coverage to a working directory. Then using ArcEdit, I added a field called "forested", joined the ids_calcs table to the attributes of CVU, and set the value of "forested" to "Y" for any polygon where "LifeForm" (LF_GSC) was set to "Tree". The explanation for the development of the LifeForm data is contained in the document, "forest_vs_nonforest.doc" in the planning files.

This step also specifies the removal of road area and stream area. The Regional Guide specifies an area of eight feet on either side of the centerline for roads and 3 feet on either side of the centerline for perennial streams. This step creates a huge computational burden on the process and will be applied after all of the other tentative suitability screens have been passed. In the statistics below, roads and streams are still included as forested lands. Roads and streams will be removed as the last step in the tentative suitability process.

Land Category	EA Acres	ORA-RIS	GIS-RIS	IRI
Net National Forest Ownership	1107671	1111961	1095269	1105015
Non-forested areas	-435852	-435797	-427088	-369666
Forested lands	671819	676164	668182	*735349

* The RIS data system only includes areas that are ten percent "occupied" by trees or greater. This 10% is related to a fully stocked timber stand. In the IRI data, we only measured the timber canopy, not the basil area of trees. It appears that the IRI definition of Forested Lands is more liberal than the RIS definition.
The Regionally recommended analysis process includes removing the area that is non-productive because of roads and streams. That step is extremely computation intensive and can be simplified on the Bighorn National Forest by delaying that calculation until all other screens for tentatively suitable timber areas have been passed. Look for the results of that analysis as the last step in the tentatively suitable timber lands analysis.

3. Congressional Designation

Lands that have been set aside as Wilderness, Research Natural Areas, or other Congressionally designated uses are removed from consideration for timber suitability. For this analysis the Cloud Peak Wilderness, Bull Elk Park Research Natural Area, and the Shell Canyon Research Natural Area are included as "withdrawn."

Land Category	EA Acres	ORA-RIS	GIS-RIS	IRI
Forested lands	671819	676164	668182	735349
Forested Wilderness	N/A	N/A	64015	84089
Forested Bull Elk Park	N/A	N/A	524	900
Forested Shell Canyon	N/A	N/A	0	580
TC 310 @ Medicine Wheel	0	N/A	226	0
Forested, withdrawn or no TC	-65003	-68311	-64764	-85570
Forested, not withdrawn	606816	607853	603417	649780

N/A – No break down was available in this category.

Land around the Medicine Wheel does not belong in this category.

4. Non-Industrial Wood

Timber lands that have cover types that are not useful as industrial wood fiber in this area are excluded from the tentatively suitable land base. The species that are useful in this area are Lodgepole pine, Ponderosa pine, Douglas Fir, Subalpine Fir, Spruce.

Land Category	EA Acres	ORA-RIS	GIS-RIS	IRI
Forested, not withdrawn	606816	607853	603417	649780
Aspen (TAA – 901)	N/A	5685	5626	9650
Cottonwood (TCW - 902)	N/A	127	151	397
Limber pine (TLI - 903)	N/A	17676	17683	14182
"Pinyon/Juniper" (TPJ - 904)	N/A	1202	1225	2842
Non-forested types	0	141		0
Total Non-industrial Species	-27196	-24690	-24685	-27071
Douglas Fir (TDF)	N/A	84662	84293	98968
Lodgepole pine (TLP)	N/A	344697	341818	315185
Ponderosa pine (TPP)	N/A	14928	14616	18513
Spruce and Fir (TSF)	N/A	138876	138006	177219
Other TC 900 sites	N/A	-4167	-4165	12824
Total Industrial wood species	579620	578996	574568	622709

5. Irreversible Damage

Irreversible resource damage in RIS is identified as Timber Component 722. There are several versions of the documentation for this item but each one attempts to identify sites based on the combination of soils and slope. The Restocking EA indicates that "Forest specialists identified certain areas that are prone to mass failures such as slumps or slides using standard road building and logging methods currently practiced on the Forest." The soil and slope combinations listed in the 1993 "Draft Suitability Key" are used in conjunction with the "landslide" coverage from the IRI product to produce the IRI column below. Even though it appears that many additional acres were removed with this process, a close review shows that most of the acres removed due to soil and slope combinations are on inoperable slopes.

Land Category	EA Acres	ORA-RIS	GIS-RIS	IRI
Total Industrial wood species	579620	578996	574568	622709
Soil and slope combinations	N/A	N/A	N/A	-81572
Landslide coverage area	N/A	N/A	N/A	-35786
RIS Component 722	-13920	-14236	-14031	N/A
Industrial wood on stable soils	565700	564760	560537	505351

6. Restocking Assurance

Assurance of restocking was the focus of an amendment to the Bighorn National Forest's 1985 Forest Plan. Accordingly, greater detail is included in this criteria and that detail is included in the table below.

For the IRI analysis, elevation and aspect information was drawn from a Digital Elevation Model with 30-meter resolution. This data results in numerous small polygons, which were removed if they were less than 5 acres.

Land Category	EA Acres	ORA-RIS	GIS-RIS	IRI
Industrial wood on stable soils	565700	564760	560537	505351
Sites above 9200 feet	55225	56318	56329	48306
Sites below 7400 feet	76133*	81049	80245	80934
7400'–7900' on S or W slope	18149	17180	16993	18988
Bottle or Foxton Soils	4782	6576	6575	2684
33% or more surface rock	2841	23591	22896	5506

Sub-Total	-157130	-184702	-183038	-156418
Site-specific additions	+2086	+N/A**	+N/A**	
Site-specific deletions	-16459	-28694	-28433	
Industrial, assured restocking	394197	351364	349067	348933

* I assumed that the number "176133" in the Restocking EA was a typographical error.

** Site-specific additions could not be separated out in this process. Site-specific deletions were counted as any sites that had made it through the key, but were still classified as timber component 710 in RIS.

7. Inadequate Response Information

Lands that are excluded with this step include sites where the information that is available cannot adequately predict the sites response to timber management practices. Although some of our suitability keys disagree, the EA titled, "Amendment to Restocking Standards Bighorn National Forest Land and Resource Management Plan" includes the following statements on page E-16:

"Category 7 - Lands for which current information is inadequate to project responses to timber management. This includes Douglas-fir stands on south west aspects. The Forest Service has had more time to evaluate management on ***these sites*** *since the original Forest plan suitability analysis and has found that regeneration is not predictable. Douglas-fir is a species used by industry and on many sites regeneration can be assured in the five-year time limit."* (emphasis added)

In the wording, which is quoted above, the words "these sites" is assumed to refer to "stands on south west aspects". As I attempt to implement this I need to decide what aspects are included in "south west" as opposed to "south and west" or "southwest". My intention is to exclude sites with a DEM generated aspect >= 180 and aspect <= 270. (That includes everything between due south and due west.)

Ponderosa pine is not mentioned, so all of the Ponderosa acres that have passed the other filters are removed here.

Land Category	EA Acres	ORA-RIS	GIS-RIS	IRI
Industrial, assured restocking	394197	351364	349067	348933
Douglas fir on south west				-6655
Ponderosa Pine	-42281	-39459	-39324	-302
Historic Tentatively Suitable	351916	311905	309743	341976

8. Non-Forested Sites - Revisited

The latest Regional process describes removing a buffer of non-productive land around highways, Forest Development Roads, and streams. These buffers consist of the highway right-of-way (66 feet on either side of the center line), the FDR road profile (8 feet on either side of the center line), and an average stream width (3 feet on either side of the center line for a perennial stream). The buffered data coverage, A-suit2, was added to the coverage Ts7done to create Ts1to8. Only those sites that were still classified as Timber Component '999' and fell within one of the buffer areas were converted to a "non-forested" timber component.

Land Category	EA Acres	ORA-RIS	GIS-RIS	IRI
Historic Tentatively Suitable	351916	311905	309743	341976
Highway buffered area				295
FDR buffered area				1310
Stream buffered area				234
Total non-forested additions				-1839
Tentatively Suitable Douglas fir				25712
Current Tentatively Suitable	351916	311905	309743	314424

Analysis and Implications

There can be no doubt that many of the suitability categories have seen dramatic changes with the change in the data sources. There was a lot of effort that went into the timber component data in RIS, and yet many of the timber component classifications are difficult to justify.

The conversion to GIS generated acreages has separated our calculated acreage from our declared acreage. The declared acreage is based upon an accumulation of surveying data known as Public Land Survey Sections. The GIS generated acreage depends upon cartographic calculations that are generated from geographic projections of a round earth on a flat surface. GIS based calculations in this analysis use Universal Transverse Mercator (UTM) coordinate system projected on the North American Datum for 1927, zone 13. The GIS data generates area in square meters and a conversion factor of 4046.856 square meters per acre is used, based on documentation in the ArcView help files. (NOTE: GIS conversion from square meters to acres can be problematic. These calculations were done in PC ArcView 3.2a by summarizing the square meters of each category and then converting to acres. Results will vary slightly with other procedures.)

Many of the classifications in this analysis should be tested and refined through monitoring of the Forest Plan. I (Mike Scanlon) strongly recommend that the Forest Plan Revision

outline the type of documentation that is required to make changes to the tentatively suitable land base.

National Forest System Lands

This data is dependent upon the Automated Lands Project (ALP). ALP is designed to follow the Public Land Survey Sections (PLSS) and the National Forest boundary follows these lines which should be tied to surveying monuments on the ground. Recent advances in surveying have caused minor changes in the position of section lines. Future editions of the tentatively suitable land base should be tiered to ALP ownership data.

Non-forested cover types

Cover type calculations are based on an interpretation of the stand components in the Integrated Data Solutions, Common Vegetation Unit data (CVU). The RIS data system only includes areas that are ten percent "occupied" by trees or greater. This 10% is related to a fully stocked timber stand. In the IRI data, we only measured the timber canopy, not the basal area of trees. It appears that the IRI definition of Forested Lands is more liberal than the RIS definition. Stands that are at the lower end of the spectrum for natural tree cover should be checked against Society of American Foresters (SAF) definitions of a forested site. Future corrections should be reflected in the Integrated Data Solutions database and the "CVU calculation" queries that interpret the stand component data.

Non-industrial wood

Some stands may have an incorrect cover type label from the CVU photo interpretations. Other changes may be caused by modifications in the way that mixed stands are classified to fit cover types. Future corrections should be based on SAF definitions and reflected in the "CVU calculation" queries that interpret the stand component data.

Irreversible damage

There were many discrepancies between the various sources that could have been used for the "irreversible damage" component. The primary options that I considered were the sites in RIS that were previously classified as timber component '722', a 'landslide' coverage that was generated in conjunction with our "Common Land Unit" (CLU) data, and a group of soil and slope combinations that were listed in the 1993 "Draft Suitability Key". In the end I used the landslide and "Key" data. Many sites that were classified as timber component 722 in RIS were in areas that had poor regeneration, but were not areas where irreversible damage occurred following our existing harvests. Our soil-based data includes "unmapped inclusions" of other soil types. If a challenge is made against our irreversible damage classification, or any other soil-based suitability classifications, I would recommend that we confirm the specific soil type on the land in question and review the pertinent part of the soil key.

Restocking assurance – elevation and aspect

The restocking classification has historically been defined based on elevation, aspect and soils. Many of the soils are identified because they are well drained and tend to be droughty. Data sources, and some site-specific changes, that were not available during the

era of the RIS database may change the way that we look at restocking assurance. A specific example is the Garland timber sale that created small openings in an area that would be classified as too low in elevation and is on a soil that is considered droughty. This area has regenerated very well. Average annual rainfall data (not available in the days of RIS analysis) shows that this site receives more moisture than most sites at this elevation. I recommend that the Forest examine this standard based on moisture, soils, and aspect instead of elevation and aspect.

Restocking assurance – percent rock

The percent rock analysis was based entirely on soil types and could very easily be too restrictive. There are several "unmapped components" to a soil classification and the soils that were excluded at this step may have had excessive rock in any of the top three soil components. The definition of excessive rock that I used was the presence of a "V" as the third character of the "surface modifier" code. According to Eric Winthers, past soil scientist for the Rocky Mountain Region, the "V" code implied the surface modification affected 35 to 60 percent of the soil texture. I would recommend that any sites that are shown as having excessive rock be examined for physical plantability on-site.

Inadequate response information

At present, all Douglas fir and Ponderosa Pine are excluded in this category. Documentation in the restocking Environmental Analysis (November, 1991) indicates that only Douglas fir stands on "south west" aspects are unsuitable. Sites on south to west aspects are given a separate code from other Douglas fir or Ponderosa Pine.

Table B-1. Reference Codes used in GIS analysis

000	Other Ownership & Unknown		714	Bottle or Foxton Soils	
001	Water bodies over 40 acres		715	33% or more surface rock	
100	Water bodies under 40 acres		722	Irreversible resource damage	
200	Non-forested areas		723	Soil and slope combinations	
201	Highway buffered area		724	Landslide coverage area	
202	FDR buffered area		740	Douglas fir on SW slopes	
203	Stream buffered area		742	Ponderosa Pine	
310	Forested Wilderness		901	Aspen (TAA – 901)	
311	Forested Bull Elk Park		902	Cottonwood (TCW - 902)	
312	Forested Shell Canyon		903	Limber pine (TLI - 903)	
711	7400' – 7900' on S or W slope		904	"Pinyon/Juniper" (TPJ - 904)	
712	Sites below 7400 feet		998	Tentatively Suitable Douglas fir	

713	Sites above 9200 feet		999	Tentatively Suitable Timberlands	

Mike Scanlon 01/28/2002

Review and modification Mike Scanlon 09/18/2002

Restocking Analysis Review

The Forest reviewed the criteria used to previously identify lands where restocking could not be assured within five years follows final harvest.

The criteria used to identify lands incapable of regenerating within five years of final harvest are:

1. Elevations above 9200 feet were identified because of low temperatures; short growing seasons, and rocky soils. Monitoring has not identified a need to change this. The analysis process describes how this was modeled with the new Forest database.
2. Elevations below 7400 feet were identified because of lack of precipitation, high temperatures, and droughty soils. The analysis process describes how this was modeled with the new Forest database.
    a. Monitoring has identified that elevation doesn't always reflect precipitation accurately. Precipitation maps and field monitoring have identified a general area that receives above average precipitation on lands below 7400 feet in elevation and adequate regeneration just east of Dry Fork and south of Lick creek on the Tongue ranger district. Specific areas monitored include the Fool creek, ghastly and garland sale areas. Because of this new information, this area will not be dropped in step 6 of stage I suitability analysis.
3. Elevations between 7400 and 7900 feet on south and west aspects were identified because of lack of precipitation, high temperatures, and droughty soils. Monitoring has not identified a need to change this. The analysis process describes how this was modeled with the new Forest database.
4. Soil Series – The Foxton and Bottle soil series are soils that have severe limitation for reforestation. The analysis process describes how this was modeled with the new Forest database. Monitoring did identify some concerns with this criteria:
    a. On the ground observations have shown a concern with the suitability criteria of eliminating all of soil map unit 38 (Sapphire-Bottle-Foxton). The Soil survey of the Bighorn National Forest, Wyoming (1986) is the basis for this discussion, it describe the Bottle and Foxton soils as having severe limitations for regeneration due to the soils moisture holding ability, with the Bottle soils too well draining, and the Foxton holding the moisture too tight. The Bottle and Foxton soils are of moderate production (32 and 35 cubic ft./acres/year). However, the largest proportion of the soil series is Sapphire at 35%, with Bottle comprising 30%, Foxton 20%, and 15% inclusions of Cloud Peak and Rock outcrops.

b. The Sapphire soils are the third most productive soil, producing 53 cubic ft./acres/year, with moderate limitations for reforestation. Monitoring has shown these soils to regenerate and produce well, with natural regeneration, with lodgepole saplings putting on over a foot of height growth each year.
c. The current soil survey doesn't separate out these soil types from the general soil map unit 38 (Sapphire-Bottle-Foxton). Because 50% of the soil map unit has severe limitations for reforestation, in the suitability analysis, the entire soil map unit was deemed unsuited for inadequate response. As a result, an estimated 3,700 acres of Sapphire soils were considered unsuited out of the total map unit estimate of 10,542 acres.
d. Field observations have identified Sapphire soils in the ghastly, garland, Dayton Gulch, and Fool creek sale areas that have shown good regeneration. Because of this new information, this area will not be dropped in step 6 of stage I suitability analysis. If during site-specific analysis areas of Bottle and Foxton soils are identified, a decision to remove these areas from suitability can be made at that time.

5. Percent rock – 33 percent or more surface rock physically limits soil surface available for seedlings establishment. Monitoring has not identified a need to change this. The analysis process describes how this was modeled with the new Forest database.

At the Forest Planning scale, assumptions are made which may not apply to on the ground conditions. Individual site-specific decisions based on field reviews may modify these assumptions and make site-specific changes to timber suitability.

Display of Timber Suitability in the DEIS

A detailed description of the analysis process used in determining timber suitability is described above. A summary of the results from this analysis is included in the Timber Environmental Consequences section of Chapter 3, with a reference to Appendix B for more information.

Table B-2 compares the various timber suitability analyses for the Bighorn Forest since 1975 to the current Plan revision. Maps of the suitable timberlands on the forest are available.

Table B-2. Historical review and summary of lands suited for timber production in GIS acres by alternative.

	Three Stage Suitability Analysis									
Classification Categories	1975 Timber Management Plan Acres*	Forest Plan 1985 Acres	Reanalysis 1991 Acres	Reanalysis 1993 Acres	2003 Reanalysis Acres, IRI					
1. Total National Forest Land	1,107,342	1,107,670	1,107,671	1,107,671	1,105,015					
Stage I										
2. Non-forested land (includes water)	-419,059	-419,388	-435,852	-437,577	-369,667					
a. Road buffer					-1,604					
b. Stream buffer					-234					
3. Forested land (1-2)	688,283	688,282	671,819	670,094	733,509					
4. Forested land withdrawn from timber production.	-19,903	-31,260	-65,003	-63,839	-85,570					
5. Forested land not capable of producing crops of industrial wood.	-127,586	-127,586	-27,196	-25,574	-27,071					
6. Forested land physically unsuitable.										
a. Irreversible damage likely to occur.	0	0	-13,920	-59,448	-116,905					
b. Cannot be restocked within 5 years.		-103,499	-171,503	-189,957	-156,417					
7. Forest land-inadequate response information.	-152,057	0	-42,281	-34,640	-6,957					
						Alternative				
8. Lands tentatively suited for timber production (3-4-5-6-7)	388,737	425,937	351,916	296,636	340,589	340,589	340,589	340,589	340,589	340,589
Stage II						A	B	C	D	E
Analysis of benefits and costs for timber production.	0	0	0	0						
Stage III										
9. Forested land not appropriate for timber production (this is a tiered filter process**)										
a. Multiple-use objectives		-62,100	-8,832	-5,165						
i. Acres not in 5.11, 5.12,5.13, 5.4 and 5.5						49,204	207,147	274,863	142,780	10,170
ii. 5.4 in 250+ acre contiguous blocks						0				
iii. 100' Riparian Buffer						12,411	5,996	2,604	8,497	13,221
v. 100' - 300' Perenial Stream Buffer						7,078	2,925	1,029	4,706	11,662
b. Other management objectives.	0	0	0	0	0					
c. Economic efficiency (logging methods)	-142,806	-97,398	-81,022	-19,411						
10. Lands suitable for timber production (8-9)	245,931	266,439	262,062	272,060	340,589	**271,895**	**124,521**	**62,093**	**184,606**	**305,535**

Suited lands by Management Area	Alternative				
	A	B	C	D	E
a. 5.11 Forest Vegetation Emphasis	88,793	46,049	56,962	75,973	31,739
b. 5.12 Rangeland Vegetation Emphasis	55,445	20,880	5,131	40,115	14,386
c. 5.13 Forest Products	147,147	57,590		68,519	108,262
d. 5.4 Wildlife Habitat - Forest Products					59,692
e. 5.5 Dispersed Recreation - Forest Products					91,457
* Definitions of suited lands were different in 1975; this is included for reference only.	291,385	124,519	62093.3	184606	305535

Forest Planning Model

Forest plan modeling was accomplished using a number of resources. Some work was done in-house at the Forest, the yield tables were completed by personnel at the Fort Collins WO detached office, and the harvest schedule modeling was done by a private contracting firm. The contractor used Remsoft's *Woodstock*© timber model. Complete documentation will be provided from the contractor.

Woodstock© was used to schedule timber harvests by decade for the next 15 decades. This long planning horizon assures a sustainable yield into the future. Most of the further analysis used data from the first five decades, averaged on a decadal or annual average.

Stratification

Land stratification is the process of identifying a set of attributes, or strata, to use in defining the land base. This is done to organize the forest land base into logical subunits that respond similarly to management actions. Many land strata were used to develop the master coverage used in the *Woodstock*© model. Forested land was stratified by cover type, size class and density as this matches the habitat structural stages used in later analysis. Additional data included watersheds, scenic integrity objectives, road construction needs, existing transportation system, stream courses, and Lynx habitat.

Silvicultural Prescriptions in the Model

Silvicultural systems were set up for the cover types harvested. In lodgepole pine, these included even aged systems of clearcuts and two-step shelterwood, and uneven-aged management using group selection on a 20 year cutting cycle. In both the spruce-fir and Douglas for cover types these included three step shelterwood and uneven-aged management using individual tree selection on a 20 year cutting cycle. Yield tables were developed using the Forest Vegetation Simulator (FVS) for these prescriptions and used in the *Woodstock*© model.

Culmination of mean annual increment (CMAI) are based on cubic merchantability specifications included in the DEIS for sawtimber and POL.

Costs and Revenues in the Model

Cost and revenues used in the model came from the *Quick-Silver* update for the Bighorn Forest, which utilized the fiscal year 1998 TSPIRS 3 year average without overhead. Conventional harvest systems were included. Un-conventional systems such as cable, helicopter, cut to length were considered. However, previous analysis done in support of the 1994 ASQ plan amendment showed that while there may be area that could utilize these systems, it is to small and scattered to be practicable.

A summary of the costs and benefits used in the model are included in the project file.

Model Constraints

Several constraints were developed for the model in response to management requirements in the NFMA regulations (36 CFR 219.27) and standards and guidelines developed for the alternatives. Constraints were also developed in response to management goals and to improve the model's simulation of actual management of the Forest. The following constraints were applied to all alternatives.

Vegetation Management:

Timber

For Lands suited for timber production in management areas 5.11, 5.12, 5.13, 5.4, and 5.5 use the following as a guide. Constraints may alter the amount of even vs. uneven aged management.

Cover Type	Spruce fir, Douglas fir	Lodgepole
Clearcut	None	5% of suited acres
Shelterwood		
Group Salvage	N/A	Used to meet SIO and elk security constraints
Individual tree selection	Used to meet SIO and elk security constraints	N/A

Post treatments (Based on past and expected actions)

Clear cut:

- Site Preparation
  - 75% broadcast burn
  - 15% pile and burn
  - 10% nothing
- 50% Planting

Shelterwood

- Prep cuts. – No post sale work
- Seed cut.
  - Site Preparation
    - 15% broadcast burn
    - 75% nothing
  - 15% Planting
- Overstory Removals

Un-even aged selection

- Group Selection
  - 20% TSI, no restriction for LAU's
  - 5% Planting
- Individual Tree Selection
  - 10% TSI, no restriction for LAU's

Other Constraints to Consider:

- Long term sustained yield, and even flow. (36 CFR 219.16)
- Ending inventory constraint. This constraint attempts to ensure that the total inventory volume left at the end of the harvest-scheduling horizon is sufficient to maintain the harvest pattern established for the given alternative. (ASQ G&Y model)
- Rotation age should be at 95% of Culmination of Mean Annual Increment. (36 CFR 219.16)
- Even-aged cut block size. (36 CFR 219.27)
    - Final harvest will not exceed 40 acres (clearcut, and overstory removal).
        - Minimum harvest site is 5-10 acres.
    - Created openings will not exceed 40 acres.
    - Potential logical harvest units must separate openings created with even-aged management. (Leave same acreage between units as cut acreage)
    - Opening is no longer an opening in 2-3 periods using FVS runs, based on: (Forest wide silviculture guideline #4)
        - In Low SIO stocking is 7 foot tall with 300 trees per acre.
        - In Moderate SIO stocking is 25% of the height of the adjacent stand with 150 trees per acre.
        - In High SIO stocking is 50% of the height of the adjacent stand with 150 trees per acre.
- Maximum financial timber loss. Just how much do we want to spend to get that timber? (ASQ G&Y model)
    - Allow 25% cost overrun on road costs vs. timber revenues.
- Maximum percentage of Spruce/fir harvest. ASQEAS limited SF harvest to <40%, see chart above. (ASQ G&Y model)

Scenery

- Constrain harvest method by SIO
    - High and moderate SIO limited to no less than 50% uneven-aged management, group or individual tree selection.
    - Low SIO has no limitations.
- The scenic integrity objective for the foreground and the middle ground of the view shed from the wild river (management area 1.5) is high (mapped). (Management area guideline for MA 1.5, scenery management #1)
- The scenic integrity objective for the foreground and the middle ground within the river corridor (the management area boundary (MA 3.4 or scenic rivers) is high. The scenic integrity objective for the river view shed beyond the river corridor is moderate (mapped). (Management area guideline for MA 3.4, scenery management #1)
- In management areas 5.11, 5.12, 5.4, and 5.5 in the foreground zone (1/4 to 1/2 mile) of concern, concern level one and two roads, trails, and use areas, the scenic integrity objective is moderate (mapped). (Management area guideline for MA 5.11, 5.12, 5.13, scenery management #1
- In areas other than those stated above, the scenic integrity objective is low. (Management area guideline for MA 5.11, 5.12, 5.13, 5.4, 5.5 scenery management #2)

Heritage

- Cultural Landscapes (9 identified).
- In areas shown in appendix (mapped) a SIO of high applies to the foreground. (Forest wide Heritage resource guideline #7)
    - Applies to 8 of 9 cultural landscapes mapped, Battle Park is not included.

Wildlife

- Elk security. (Forest wide wildlife guideline #6)
    - Define Elk Security.
    - Retain between 20 and 60% of geographic area (mapped) in Elk Security.
    - Retain 40% Elk Security Forest wide.
    - Harvest is allowed in Elk Security, if post harvest still meets Elk Security definition.
        - Limits harvest to uneven-aged management.
        - All new roads will be closed post harvest.
        - No limitation on % of Elk Security block entered.
        - Only change in Elk security will be from level 2 road construction that will not be decommissioned.
    - Snags and coarse woody debris guidelines were incorporated into the growth and yield tables, and did not need to be further modeled.
- Lynx. (Based on latest draft of lynx amendment)
    - After analysis, the lynx constraints below were determined to be non-binding to the model, and were checked post processor.
    - If more than 30% of lynx habitat (coverage mapped) within a LAU (coverage mapped) is currently in unsuitable condition (HSS 1t or 2t), no further reduction of suitable conditions shall occur as a result of vegetation management projects proposals. (Conservation measures applicable to all programs and activities, Programmatic planning standard #5)
    - Within a LAU, maintain denning habitat
        - Defined as:
            - Lodge pole Spruce/fir, Douglas fir HSS 4c
            - Slope less than 40%
            - Aspect NW to NE (315-360, 1-45)
            - Generally larger than 5 acres,
            - Comprising at least 10% of lynx habitat.
        - Where less than 10% denning habitat is currently present within a LAU, in stands that have the highest potential for developing denning-habitat structure (HSS 4b), defer any management actions that alter vegetation such as timber sales, salvage sales, and prescribed fire. (Conservation measures applicable to all programs and activities, Project planning standard #2) (Wildland fire management project planning standard #6)
    - Timber management practices such as timber harvest and salvage sales shall not change more than 15% of Lynx habitat within a Lynx Analysis Unit (LAU) to an unsuitable condition (HSS 1t or 2t) within a 10-year period. (Timber management project planning standard #1)
    - In Lynx habitat, pre-commercial thinning will be allowed only when stands no longer provide snowshoe hare habitat (e.g., self-pruning processes have eliminated snowshoe hare cover and forage availability during winter conditions with average snow pack). This is reflected in the bare ground yield

tables which will not schedule TSI until height to crown is 2 feet. (Timber management project planning standard #3)

Biodiversity (Forest wide biodiversity guideline #3)

- Schedule harvest to obtain HSS diversity by geographic area to create:
  - Early structural stages, 5% in HSS 1 or 2.
  - Old Growth HSS,
    - In cover types except SF, 10% in HSS 5.
    - In Spruce/fir, 15% in HSS 5.
    - First decade run will designate the above HSS 5s for the planning period.
      - Percentage by cover type will be proportional to the occurrence of that cover type in the geographic area that meets definitions below. If there is insufficient acres use closest surrogate.
      - Lodgepole HSS 5 = 4a, b, c and 151+ years old.
      - Spruce/fir, Doug Fir HSS 5 = 4c and 200+ years old.
      - Ponderosa, Limber pine HSS 5 = 4a, b and 161+ years old.
      - First choice for designation will be non-suited lands.
      - The HSS 5 will be retained throughout the planning period.

Benchmark Comparison of Model Outputs

The outputs for this model were compared with the results of the 1985 Forest plan projections, actual accomplishments and projections from the unimplemented 1994 ASQ EIS amendment.

Total Sale Quantity

Achievable Volumes

The Bighorn National Forest last met or exceeded its ASQ in 1988. For over a century since the early 1900's the Forest has averaged approximately 5 million board feet (MMBF) per year. Recent lows in the last 5 years have been attributed primarily to appeals, lawsuits, litigation and budget. In 1996 a letter to the Wyoming congressional delegation from then regional forester Elizabeth Estill limited the green sawtimber sale offer on the Bighorn Forest to 4.5 MMBF, 3.0 MMBF of firewood, and 1.0 MMBF for other management purposes (ski area expansion, salvage, etc.). Since the Forest Plans inception the average annual total programmed offer is 7.88 MMBF (1.97 MMCF) per year (USDA-FS, 2002 monitoring report).

Total Sale Quantity

Total sale quantity (TSQ) includes all the volume expected to be offered from the Forest, and includes both sawtimber and all other productgs or Products Other than Logs (POL). The Forest has and expects to continue to offer a variety of timber sales. Some are primarily sawtimber, others are multi-product sales which include sawtimber and POL depending on the resource needs of the treatment area. TSQ includes volume removed

from suited and unsuited lands. Harvests from unsuited lands could include harvests for fuel treatments, scenic vistas, developed recreation expansion, and wildlife habitat improvement on non-suited lands. The Forest will also offer personal use firewood and post and pole permits, actual firewood sale levels were used to estimate future sale levels, given the amount of lands available and access to them for such activity.

Updates not included in current version of the model:

- Just the Woodstock (semi-spatial) portion has been run, the Spatial Stanley portion has not, and expectations are that volumes may fall when clearcut size and green up time (when an opening is no longer considered an opening) is modeled.
- The coverage FTG is using is somewhat dated, as it was sent prior to a number of decisions made. It doesn't represent the current:
    - 5.4, 5.5 management areas
    - GWIZ (100-300') areas in 5.13 available for management.
    - Cultural landscapes are modeled with the scenic constraint of SIO modification (no more that 50% even aged management).
    - SIO in 5.13.
- Elk security is modeled at 40% forest-wide.
- Bio-diversity is modeled forest and suited:
    - HSS 5 is modeled Forest-wide (15% S/F, 10% all other forested).
    - Early HSS is modeled for Suited lands only (they are the only ones that can create HSS 1,2) It is not possible to meet this guide with harvest alone given the limited amount of management we do in comparison to the total forested acres.
- Road costs are a constraint, but as modeled the <u>total road cost for any period</u> can exceed revenue by 25%.
- The program is set to optimize harvest and balance revenue.
- Total S/F harvest is constrained to no more than 40% of total.
- Long term sustained yield and non declining even flow are constraints.
- Total cost of each alternative (FS $) is not displayed, but data indicates that A and E would require additional resources above current funding levels.

Fire Hazard and Risk Analysis

Fire Hazard Analysis

The potential for wildland fire is measured in terms of fire hazard and resistance to control. In an effort to model fire behavior, fire managers have developed fire behavior modeling systems, of which the NFDRS (National Fire Danger Rating System) and the FBPS (Fire Behavior Predication System) models are among the most commonly used.

NFDRS is used as an indicator of potential fire behavior across analysis areas which may include many thousand of acres. FBPS is useful for more site-specific applications. The FBPS model illustrates the differences in fuels and how they react to such factors as wind, humidity, and topography in natural or management ignited fire. Output from the FBPS can be rated based on relative resistance to fire suppression activities. The classifications used are usually low, moderate, high, and extreme and are routinely a function of flame length, rate of spread, or intensity. Low resistance to control typifies fires that are relatively easy to suppress in the shortest time frames while high resistance fuels are usually older age conifer fuel types or shrub fuels with significant fuel loadings which can produce extreme flame lengths and fire intensities that exceed the capability of direct fire suppression actions.

In an effort to model fire hazard on the Bighorn NF, a forest-wide analysis was completed using GIS (Geographic Information System), FlamMap (Finney 2000) and RMRIS (Rocky Mountain Resource Information System), and CVU (Common Vegetative Units). FlamMap is a computer program that produces fire behavior values (e.g., rates of spread, flame lengths) based on weather and physical characteristics of the ground and allows the user to produce fire behavior maps. For this analysis, the flame length value was used due to the relationship between flame length and fire intensity and their implications to fire suppression.

The objective of this hazard analysis is to quantify flame length, using 90th percentile weather[1], across the landscape. The resulting flame lengths are then grouped into four categories: (1) low – flame lengths four feet or less, (2) moderate – flame lengths greater than four feet and less than or equal to eight feet, (3) high – flame lengths greater than eight feet and less than or equal to ten feet, and (4) extreme – flame lengths eleven feet and greater. These groupings are commonly used fire behavior thresholds.

Methods for Determining Fire Hazard GIS was used to create a fuel model layer (collection of fuel properties; e.g., fuel loading, fuel bed depth) based on the standard Fire Behavior Prediction System (FBPS). Fuel models are simply tools to help the user realistically estimate fire behavior {Anderson 1982}.

[1] 90th percentile weather represents days when the fire danger is very high to extreme—a combination of low humidity, high temperature, and high winds.

Prior to running FlamMap, crown base height (CBH), crown bulk density (CBD), and stand height were determined for each fuel model identified on the forest. This enables the model to calculate surface to crown fire transition, as well as crown fire behavior. Due to the number of RIS location/sites across the forest and the time required to calculate CBD, CBH and stand height, data for sites were averaged for each fuel model and cover type. CBD, CBH and stand height was then calculated for each representative stand.

FlamMap also requires live and dead fuel moistures for each fuel model as well as wind speed and direction. A historic weather analysis was completed to determine these variables. Historical weather data was collected from the Burgess, Hunter, Schoolhouse Park, and Mill Creek Remote Automated Weather Station (RAWS). Weather data was downloaded from the Weather Information Management System (WIMS) data base and processed with Fire Family Plus (USDA Forest Service, 2000) using an annual filter of June 16 through October 5 which represents the Bighorn fire season. It should be noted this percentile can be approximated to seasonal fire behavior nomenclature, where 90th percentile equates to drought conditions. Average windspeed was calculated by FireFamily Plus. Note that surface wind speed is often the most critical weather element affecting fire behavior and fire danger. It is also the most variable and, consequently, the hardest to evaluate. Air moving across the surface of the land constantly changes in both speed and direction. Over a period of time, one observes a series of gusts and lulls in the wind speed. Winds that persist for 1 minute can affect gross fire behavior, including rate of spread and fireline intensity. Momentary gusts, on the other hand, have little effect on the overall rate of spread or intensity. However, they can produce large, temporary fluctuations in flame height and can easily trigger crowning or throw showers of embers across the fireline. Both probable maximum one-minute gust and the probable momentary gust are displayed. For the analysis, both the probable maximum one-minute speed and probable momentary gust were used as both play important roles in fire behavior. Probable Maximum 1-minute windspeed was used because winds that persist for one minute can affect gross fire behavior, including rate of spread and fireline intensity, thereby affecting surface to crown fire initiation and transition.

Once all the input data had been determined, FlamMap was run and a map generated, indicating flame lengths across the landscape. This map was then exported out to arc-info in the ASCII/raster format and processed in arc-grid, where flame length per number of acres (percent of vegetated area by flame length) was determined.

Limitations of the hazard analysis (1) Since CBD, CBH and tree height were only calculated on the "average" site for each cover type and subsequent fuel model, the analysis underestimates fire behavior at the upper end for each fuel model, especially is it relates to surface to crown fire initiation, transition and canopy fire behavior. As a result the number of acres in the extreme, high and moderate hazard classes are underestimated, with acreages the latter two being most effected by surface to crown transition and canopy fire behavior.

(2) The above analysis will not account for any future changes in vegetation due to insect epidemics or disease outbreaks.

(3) This is a broad scale assessment of fire hazard. Site-specific analysis, using more detailed site-specific information, may potentially yield more accurate fire behavior results.

Fire Risk Analysis

To further evaluate fire's relationship to overall forest management and protection, fire hazard was related to risk. Risk relates to the source and number of ignitions, which can result from either human-caused or natural caused (i.e. lightning) ignitions. Although fire risk is simple to calculate, it is difficult to predict, especially with human-caused ignitions.

Fire risk is the simple measure of fire starts on a 1,000-acre basis per ten year period (per decade). The fire risk value corresponds to a likelihood of fire starts per 1,000 acres per decade. The following are risk ratings and range of values used to categorize risk.

Low Risk: 0 to 0.49 – This projects a fire every 20 or more years per thousand acres.

Moderate Risk: 0.5 to 0.99 – This projects one fire every 11 to 20 years per thousand acres.

High Risk: ≥ 1.0 – This level projects at least one fire every 0 to 10 years per thousand acres.

This analysis used all data available in the historical fire occurrence database. This database contains fires from 1970 to 1996 on which suppression action was taken and a Individual Fire Report (FS-5100-29) completed and submitted.

In an effort to quantify risk for this analysis, fire occurrence records were obtained and processed in GIS. The fire locations were plotted and overlaid on a Forest map. Three geographic areas were identified, where fire occurrence appeared to be somewhat similar and homogeneous throughout the area. Fire risk was then calculated for each of the three areas based on historic fire occurrence.

Fire Regimes and Condition Classes The fire regime groups and conditions class classifications were determined from Forest Integrated Resource Inventory (IRI) and Common Vegetative Unit (CVU) stand polygon data. The classifications were based on definitions presented by Wendel Hann and David Bunnell in *Fire and Land Mangement Planning and Implementation Across Multiple Scales, 2001.*

Fire Use and Appropriate Management Response Fire has and will continue to play a role in the structure, occurrence and condition of vegetative communities on the forest. Under the current Bighorn Land and Resource Management Plan (1985), the only management response to an unplanned wildfire ignition is a suppression strategy. One of the objectives of this revision is to establish a range of acceptable appropriate management response (AMR) actions. Assigned to each Management Area prescription in the revision, is a menu of AMR actions (direct control, perimeter control, and/or prescriptive control).

On the Forest, every area with burnable vegetation will have an AMR assigned to it. The parameters under which each AMR is managed are outlined in the FMP (Fire Management

Plan). When the FMP has been completed and approved, all ignitions will receive the full extent of management options available, depending upon resource management objectives presented in the FMP. These options range from monitoring with minimal on-the-ground actions to intense suppression actions on all or portions of the fire perimeter. The appropriate management response is developed from analysis of the local situation, values to be protected, management objectives, external concerns, and land use. The Forest Plan is a decision document, where the Fire Management Plan is a implementation document. Note that current direction allows for a change in strategy from a wildland fire use strategy to a more restrictive strategy such as confinement. For example, assume the Forest Plan assigns an AMR of prescription control to a specific area, however, during subsequent development of the FMP, it may be determined that direct control is a more suitable AMR due to the small size of the area and/or the proximity of values at risk. One may not deviate from a containment strategy, such as direct control, to a fire use strategy, such as prescription control.

Acres Burned by Wildfire

It is very difficult to predict the number of acres that will be burned by wildfire in future years. Conditions that dictate the severity of fire seasons tend to vary significantly year to year. Weather, which is the primary influence on availability of fuels for ignition, is very difficult to predict with any degree of reliability more than a few days into the future. Research suggests that large stand-replacing fires are more likely to occur because of weather conditions than fuel accumulations. Most large fires occur in years with elevated weather variable values and fires in those years account for >99% of the area burned {Bessie and Johnson, 1995}. Prediction of major influences, such as the occurrence of drought, is improving, but is still not very reliable. For these reasons, the best method for predicting the number of acres that will burn in the future is to base the prediction on historical fire occurrence.

In an effort to predict the number of acres that will be burned in the future, in a decade, the fire probability analysis program PROBACRE {Wiitala 1999} was utilized. This program assesses the risk of catastrophic consequences from a single wildfire or series of wildfire events. PROBACRE calculates the probability of a major single event, or multiple fire events, and the long-term probability that a combination of fire events, both large and small, would result in a total burned area in excess of a particular number (user-specified). The probabilities are calculated from historic fire information for annual frequency of fires by size class.

The PROBACRE analysis period was 10 years. The probability analysis was completed for the Bighorn Mountain Face, Bighorn Montane Area Above 7000 Feet, Cloud Peak Wilderness, and for the Bighorn National Forest, as a whole.

Analysis of Rangeland Capability and Suitability for Livestock Grazing

Range Analysis

Requirements to perform analysis of rangeland suitability are found in NFMA at 16 U.S.C. 1604(g)(2)(A) and 36 CFR219.20. FSM 1905 contains a definition of "Lands Suitable for Grazing and Browsing" as lands with vegetation that can be used by grazing animals, both domestic and wild herbivores, without damage to the soil and water values.

The Code of Federal Regulations (CFR) contains several provisions dealing with rangeland capability and suitability. Specifically, 36 CFR 219.3 provides definitions as follows:

Capability: The potential of an area of land to produce resources, supply goods and services, and allow resource uses under an assumed set of management practices and at a given level of management intensity. Capability depends on current conditions and site conditions such as climate, slope, landform, soils, and geology, as well as the application of management practices, such as silviculture, or protection from fire, insects and disease.

Suitability: The appropriateness of applying certain resource management practices to a particular area of land, as determined by an analysis of the economic and environmental consequences and the alternative uses foregone. A unit of land may be suitable for a variety of individual or combined management practices.
The 36 CFR 219.20 contains the following direction about grazing resources in Forest planning:

- In Forest planning, suitability and potential capability of NFS lands for producing forage for grazing animals and for providing habitat for indicator species shall be determined as provided in paragraphs (a) and (b) of this section. Lands so identified shall be managed in accordance with direction established in Forest plans.
- (a) Lands suitable for grazing and browsing shall be identified and their condition and trend shall be determined. The present and potential supply of forage for livestock, wild and free roaming horses and burros, and the capability of these lands to produce suitable food and cover for selected wildlife species shall be estimated. The use of forage by grazing and browsing animals will be estimated. Lands in less than satisfactory condition shall be identified and appropriate action planned for their restoration.
- (b) Alternative range management prescriptions shall consider grazing systems and the facilities necessary to implement them; land treatment and vegetation manipulation practices; evaluation of past problems; possible conflict or beneficial interactions among livestock, wild free-roaming horses and burros and wild animal populations, and methods of regulating these; direction for rehabilitation of ranges in unsatisfactory condition; and comparative cost efficiency of the prescriptions.

The process used for determining rangeland capability and suitability is outlined in the Region 2 desk guide "Rangeland Suitability for Livestock Grazing at the Forest Plan Level and Standards for NEPA display

Capability and suitability were determined through the use of Geographic Information Systems (GIS) technology. Based on the nature of GIS, acreage for each feature considered not capable or unsuitable is systematically eliminated from the suitable base one layer at a time. Overlapping features are subtracted only once to prevent double counting of acres. As an example, on a heavily forested developed recreation site, if the site is entirely forested, all the acres are eliminated at the dense forest canopy layer, once subtracted those same acres are no longer available to be subtracted at subsequent levels (i.e. under the developed recreation site layer). This explains why the acreage deducted in Table A and Table B for a specific feature may be somewhat less than the total acres for that feature.

Rangeland Capability Capable rangelands are those lands that are accessible to livestock, produce forage, or have inherent forage producing capability, and can be grazed on a sustained basis. To determine acres capable of supporting livestock, land was systematically eliminated from the gross National Forest System (NFS) lands as follows in Table B-3. Rangeland capability does not vary by alternative.

Table B-2. Acres of land determined as capable for livestock use.

Classification/Description	Acres Deducted	Running Totals
Net National Forest System Acres	-------	1,105,017
Deductions for other than capable acres	-------	1,105,017
-Soil types that are dominated by a large percentage of rock outcrop	332,346	772,671
-Lands that are not capable of producing 200 pounds of forage per acre	63,048	709,623
-Lakes, reservoirs, ponds, and marshes	11,913	697,710
-Major rivers within the Bighorn National Forest proclaimed boundary	0	697,710
-Perennial streams	338	697,372
-Roads and highways	1371	696,001
-Slopes greater than 60% (not capable sheep or cattle)	25,601	-------
-Slopes between 41%-60% (not capable cattle)	9,137	-------
Total capable for sheep grazing	434,617	670,400
Total capable for cattle grazing	443,754	661,263

Rangeland suitability Suitability is the appropriateness of applying certain resource management practices to a particular area of land, as determined by an analysis of the economic and environmental consequences and the alternative uses foregone. A unit of land may be suitable for a variety of individual or combined management practices. The suitability analysis is presented in two parts: current suitability and suitability by Forest Plan alternative. To determine acres present environmentally suitable for livestock grazing, land was systematically eliminated from the net National Forest System Lands using GIS technology as shown in Tables B-4 and B-5.

Table B-4. Acres of land determined as suitable for livestock use.

Classification/Description	Cattle		Sheep	
	Acres Deducted	Running Totals	Acres Deducted	Running Totals
Net National Forest System Acres	------	1,105,017	------	1,105,017
Deductions for other than capable acres	443,754	661,263	434,617	670,400
Deductions for other than suitable acres	------	661,263	------	670,400
-Existing canopy cover >70%	395,792	265,471	395,792	274,608
-Shell Canyon and Bull Elk Park RNA's that exclude livestock	1618	263,853	1618	272,990
-Range exclosures	3586.9	260,266.1	3586.9	269,403.1
-Forage not available due to right-of-way fences & other limitations	1172.8	259,093.3	1172.8	268,230.0
-Current grazing closures	0	259,093.3	0	268,230.0
-Threatened, Endangered, and Sensitive Species Closures	0	259,093.3	0	268,230.0
-Other incompatibilities	0	259,093.3	0	268,230.0
-Economical Feasibility	0	259,093.3	0	268,230.0
Total suitable acres (cattle)		259,093.3		------
Total suitable acres (sheep)		------		268,230.0

Table B-5. Acres determined at the forest plan level as suitable for livestock use.

Classification/Description	Acres Suitable
Total Suitable Determination Acres for Cattle grazing	259,093
Total Suitable Determination Acres for Sheep grazing	268,230

Suitability by Alternative:

Livestock grazing has not been identified as an inappropriate activity in any management

prescriptions, although it may be limited in Research Natural Areas when establishment records are developed. Acres suitable for grazing do not vary by alternative.

No alternatives under consideration propose to permanently close any allotments to domestic livestock grazing.

Economic Analysis:

Forest-wide standards and guidelines for grazing identify desired resource conditions across all alternatives. To achieve these desired resource conditions, specific grazing systems, stocking rates, needed structural, non structural range improvements and coordination with other resources are developed at the allotment management planning level based on the site specific conditions. Presently there are numerous grazing systems being use on the forest, including but not limited to, multi pasture rotational, deferred rotational, rest rotational, alternate year, once over lightly, high intensity, short duration and to a limited degree continuous.

Livestock grazing was not identified as a major revision topic in this Forest Plan. Differences between alternatives are primarily based on the differences in standards and guidelines between management prescriptions, and the mix of acreages of prescriptions between alternatives, rather than how those livestock are to be managed. Therefore, a detailed examination of every available grazing system for each of the alternatives was not warranted. For purposes of analysis, the financial and economic consequences of two grazing prescriptions are compared in Table B-6.

Prescription A: This prescription is representative of lands managed under active grazing. This prescription looks at Forest-wide standards and guidelines and management area direction needed meet resource goals and objectives. Grazing systems are developed within this direction at the site-specific level. Range improvements are maintained at grazing permittees expense. Existing improvements that have reached the end of their physical life span would be reconstructed as needed or removed. New improvements are approved on a case-by-case basis. Forest-wide standards and guidelines are designed to improved unsatisfactory range condition. Areas in unsatisfactory condition become satisfactory through mitigation identified during site-specific analysis. Noxious weed management would continue at present levels. Vegetation treatment with prescribed fire would be conducted primarily for wildlife habitat improvement and fuels reduction. In general, forest-wide stocking is expected to remain fairly constant at or near 2.5 acres/head month. Vacant allotments remain in vacant status until site-specific analysis can be completed.

Prescription B. Currently grazed lands would be managed without grazing. Current grazing permits would be cancelled or not reissued at end of current term. All existing range improvements not needed for other resources or needed to prevent livestock trespass from adjacent lands would be removed. Noxious weed management would continue at present levels.

Table B-6. Financial and economic comparison of grazing prescriptions.

Grazing Prescriptions	Average Profile for Lands Managed for Active Grazing	Average Profile for Lands Currently Grazed, but No Longer Managed for Grazing
Estimated Grazing (Annual Average, 2001-2010)		
Sheep: Head Months per Acre	.32 BNF	0
Animal Unit Months per Acre	.22 BNF	0
Cattle: Head Months per Acre	.109 BNF	0
Animal Unit Months per Acre	.425 BNF	0
Financial Analysis (taxpayer/agency perspective)		
Revenues per Acre per Year		
Sheep	$0.47	--
Cattle	$0.25	$0.00
Costs per Acre per Year		
Sheep	$0.47	--
Cattle	$1.02	$0.27
Net Revenue per Acre per Year		
Sheep	$0.00	---
Cattle	-$0.77	-$0.27
Present Net Value Per Acre in Decade 1		
Sheep	-$3.34	---
Cattle	-$6.82	-$2.31
Economic Analysis (society perspective)		
Benefits per Acre per Year		
Sheep	$1.11	--
Cattle	$2.40	$0.00
Costs per Acre per Year		
Sheep	$2.23	--
Cattle	$3.11	$0.27
Net Benefit per Acre per Year		
Sheep	-$1.12	--
Cattle	-$0.71	-$0.27
Present Net Value per Acre in Decade 1		
Sheep	-$10.15	--
Cattle	-$6.98	-$2.31

Source: Data derived from the White River National Forest unless otherwise noted

The economic analysis was completed from two perspectives: Financial efficiency and cost effectiveness. Financial considerations include only those revenues received by and costs incurred by the Forest Service. Economics considerations include the benefits and costs of grazing to all of society. Economically, actively grazed lands benefit society by providing food and fiber, and employment. These calculations do not include benefit or costs for

which monetary values are unavailable.

Based on the information discussed above, certain rangelands were determined to be suitable for livestock grazing. The results of this determination are summarized in Tables B-7 and Tables B-8. Not all of these lands will be stocked, but all are considered available for grazing.

Table B-7. Acres suitable for cattle grazing by alternative.

	Alt A	Alt. B	Alt. C	Alt. D	Alt. E
Acres presently suitable for cattle grazing	259,093	259,093	259,093	259,093	259,093
Management area prescriptions Excluding Grazing	0	0	0	0	0
Acres proposed for full or partial closure in this alternative	0	0	0	0	0
Total Environmentally Suitable Acres (cattle) for this alternative	259,093	259,093	259,093	259,093	259,093
Economically unsuitable for Cattle	0	0	0	0	0
Suitable Acres for Cattle Grazing	259,093	259,093	259,093	259,093	259,093

Table B-8. Acres suitable for sheep grazing by alternative.

	Alt A	Alt. B	Alt. C	Alt. D	Alt. E
Acres presently suitable for cattle grazing	259,093	259,093	259,093	259,093	259,093
Management area Prescriptions Excluding Grazing	0	0	0	0	0
Acres proposed for full or partial closure in this alternative	0	0	0	0	0
Total Environmentally Suitable Acres (sheep) for this alternative	268,230	268,230	268,230	268,230	268,230
Economically unsuitable for Sheep	0	0	0	0	0
Suitable Acres for Sheep Grazing	268,230	268,230	268,230	268,230	268,230

Alternative Uses Foregone

An analysis of alternative uses forgone is required in the planning document based on how each of the alternatives deals with the findings of suitability. This analysis is expressed in terms of the effects of continuing to permit livestock grazing of existing lands, or to permit livestock grazing of any lands not currently authorized under permit, and the potential effects that permitting grazing would have on the elimination or restriction of other activities or resource values.

For example, a decision to potentially allow livestock use of a given area means that forest visitors desiring to experience a wildland free of human influences would not be able to do so on the given area of land. Conversely, decisions to eliminate livestock grazing from any lands where it is currently authorized, or potentially could be authorized, may have effects on values such as local community stability, rural lifestyle, open space protection, and so forth.

The analysis of uses forgone must detail the effects of the alternative actions with regard to the tradeoffs associated with decisions regarding permitted grazing or no grazing to the extent that those decisions preclude or restrict other resource uses and values.

There are some areas of land within the Forest that are not planned by a specific alternative to have permitted livestock grazing for various reasons. Areas such as developed campgrounds and administrative sites (except for administrative pack and saddle stock pastures) are not generally considered to be suitable for livestock grazing. There are also areas on the Forest where no livestock grazing allotments exist due to various administrative reasons such as conflicts with recreation, access limitations, etc. These areas are common to all action alternatives. Under the No Grazing alternative, all acres are considered to be unsuitable for livestock grazing during this planning cycle.

The economic analysis was completed from two perspectives: Financial efficiency and cost effectiveness. Financial considerations include only those revenues received by and costs incurred by the Forest Service. Economics considerations include the benefits and costs of grazing to all of society. Economically, actively grazed lands benefit society by providing food and fiber, and employment. These calculations do not include benefit or costs for which monetary values are unavailable.

Returning to the CLU copy used in step number 2, in the same ArcEdit session, I selected these soil types and set the value of “r-suit” to “low produc”. All polygons that did not have a value in the “r-suit” field were then set to “capable”.

The results of calculations 2 and 3 were then summarized through the ArcInfo operation called “dissolve”. The CLU coverage was dissolved based on the “r-suit” field to produce a coverage called r-suit2and3.

4. Standing water

Areas that consist of lakes, reservoirs, ponds, and marshes are eliminated in this step. The GIS library coverage called p_hydro and filed under physical/cwu is the source for this data. Using a copy of this data, a data item called "census" was added to polygon attribute file. (Census water is a classification that was needed for the calculation of suitable timber lands.) An ArcEdit session was used to populate the field called census and identify water polygons of all sizes.

The results from step 4 were combined with the results from step 1. These analysis steps were previously completed for timber suitability analysis and the results were used here for range capability analysis. Documentation of the precise ArcInfo steps can be found in the t-suit-water.aml. The output from steps 1 and 4 was stored in a coverage called ts-temp3 and the field called T_component was used to summarize the results. The following table shows the interpretation of the T-Component field for this intermediate result.

Description	T_Component Code
Areas outside of the proclaimed boundary	Null or Blank
Non Forest Service ownership	"000"
"Census" water (greater than 40 acres)	"001"
"Non-Census" water	"100"
All other Forest Service lands	"999"

At this point I switched to running some operations using the ArcGIS or Arc version 8.0 software. Operations that required large amounts of computer resources (especially RAM memory, file space, and processing time) were easier to track and complete using the latest version of the software.

I used the menu option for Tools -> GeoProcessing Wizard -> Union to combine the "r-suit2and3" coverage with the "ts-temp3" coverage. Additional coverages were added before I continued to edit the "r_suit" field.

5. Major Rivers

No major rivers exist within the proclaimed boundary for the Bighorn National Forest. The Big Horn River on the west side of the Forest is an example of a major river.

6. Perennial Stream

Perennial streams are represented by the data item "cff_code" = 402 in the GIS library coverage called "L_HYDRO" in the physical/cwu directory. Perennial streams should

have a buffer of three feet on either side of the digitized line. In the buffer operation, I translated that to one meter.

Attempts to buffer in Arc 7.X or ArcView 3.X resulted in unusable coverages and attempts to exceed the space allocation for the working directory. This was one of the primary reasons for moving to Arc 8.X. Buffering in Arc 8.X is done through the "Buffer Wizard". In my first attempt, I included the "dissolve" option for the resulting buffered polygons. While tracking the progress of this operation, I noticed that the actual buffer went fairly quickly but the dissolve seemed to drag on forever. I aborted that operation and ran the buffer without dissolving the results. The results were called "stream_buf" and were stored as a "shapefile".

7. Roads

The process of excluding roads was made up of two steps. The first step was a buffer of eight feet on either side if the center line for all National Forest "system" roads. The GIS library coverage called "op1_5" in the infra directory was used to identify the "system" roads. Eliminating trails and "unclassified roads" from the total "travel_route" network created the op1_5 coverage. I buffered each road by eight feet (2.44 meters) on each side. Op1_5 data represents the "operational maintenance level" for each of the roads on the Forest. Future versions of this data might be improved by adjusting the buffer width according to the maintenance level.

The second step was a buffer of the state highways. Highways 14, 14A and 16 bisect the Bighorn National Forest. In some places the road right-of-way and fence line are placed as much as 100 feet from the centerline of the highway. The most recent construction calls for a right-of-way and fence line that is 20.1152 meters from the centerline. There are also some areas where no fence exists, although these areas are being eliminated as new construction projects are completed. Through discussions with Phil Fessler, we chose to buffer all of the highways by 20.1152 meters. These may overestimate the amount of land that is not capable of range production, but it should accurately represent the land that is not suitable for range production.

Road and highway buffers were created separately using the Buffer Wizard in ArcMap. These results were combined first with each other and then with the stream buffer from step number six using the GeoProcessing Wizard in ArcMap. Two more coverages were also combined to these results. The r-suit2and3 coverage and the ts-temp3 coverage were added using the Union operation in the GeoProcessing Wizard in ArcMap. The results were called "r-suit1to7".

The r-suit1to7 shape file originally had 44,352 polygons. In order to clean up the shape file and simplify, I used ArcView 3.X on the server to select polygons and "calculate" values to populate the "r-suit" field in the shape file. This could be scripted in ArcEdit, but I used ArcView to provide quick displays of the selected items and simple calculation statements. Calculations were done in the following order:

a) Select T_Component = "" (no data), then set r_suit = "outside"
b) Select T_Component = "000", then set r_suit = "non-NF"

c) Select T_Component = "001", then set r_suit = "water"
d) Select T_Component = "100", then set r_suit = "water"
e) Select Bufferdist <> 0 and r_suit = "capable", then set r_suit = "highway" (The choices for Bufferdist are 0 or 20.1152)
f) Select Bufferdi_1 <> 0 and r_suit = "capable", then set r_suit = "roads" (The choices for Bufferdi_1 are 0 or 2.44)
g) Select Bufferdi_2 <> 0 and r_suit = "capable", then set r_suit = "stream" (The choices for Bufferdi_2 are 0 or 1.00)

After all of these edits were completed, the coverage was simplified with the dissolve command. The new coverage was called r-suit7.

8. Non-capable slopes

Slopes in excess of 40% are not capable of supporting cattle. Slopes in excess of 60% are not capable of supporting sheep or cattle.

I used the "bhslope_i" grid from the library directory called "dems" and "reclass"ified the slope percentages to match the non-capable slope categories listed above. Slopes of 0 to 40 percent were labeled with a slope class of 20, 40 to 60 percent with 50, and 60 percent or greater with 80. Then I used the "gridpoly" command to create a polygon coverage of the non-capable areas.

Areas less than one acre in size (four or fewer 30-meter grid cells) were removed with the "eliminate" command. The remaining polygons were combined with r-suit7 to make r-suit8. Lands that were listed as "capable" after step 7 either remained capable, were listed as sheep_only, or were listed as steep.

GIS Operations for Steps 6, 7 and 8

GIS buffer operations for perennial streams, roads, and highways are identical in the timber suitability process and in the range capability process. Refer to the timber suitability documentation for a description of the process used to create the "a-suit2" coverage. I combined the a-suit2 coverage with the r-suit4done coverage to create the r-suit1to8 coverage. I then moved all of the pertinent labels into the "r-suit" data field and used the dissolve command to create the simplified version, called r-suit8done. These steps were added to the file "r-capability.aml".

Rangeland Suitability Analysis

GIS Process Documentation

Rangeland Suitability Analysis is described in the "Region II Desk Guide for Forest Planning". The documentation of the process begins on page G.10 and the chapter is dated February 13, 2002. Major headings in this document represent the steps defined on pages G.10 through G.12.

The processes outlined below were executed using Workstation ArcInfo on an IBM desktop PC running the Windows 2000® operating system.

1. Capable Rangelands

The process begins where Rangeland Capability stops. The coverage to begin with is called r-suit8a, the data item to look at is capable, and the values to look for in the capable field are "capable" or "sheep only". This data is currently stored on the Bighorn computers at: "J:/fsfiles/office/bhgis/temp/planning". Capable rangelands have been screened for areas of streams and roads. These route buffers create a huge computational burden in GIS operations. The first step in the suitability process was to remove these categories from the capable range lands. They will be added back at the end of the process.

2. Trees and Unpalatable Shrubs

The Common Vegetation Unit coverage has information on the cover types and canopy cover throughout the Bighorn National Forest. However, the data that is stored with the coverage is limited to polygon reference information. The meat of the data is stored in an INFO file called "ids_cvu_calcs". This data has been duplicated from an Oracle table with the same name.

The Desk Guide process calls for evaluation of the canopy cover percent for trees and unpalatable shrubs. The CVU data actually contains data on the canopy cover percent for grasses and forbs, but identifying species for shrubs can be more difficult. Only those stands where the canopy cover of grasses and forbs exceeds 30 percent are classified as capable of supporting livestock management.

3. Management Area Prescriptions Excluding Livestock

Management Area Prescriptions that would exclude livestock use include Research Natural Areas (RNA's) where the establishment record precludes livestock use. All other Management Areas on the Bighorn National Forest allow for livestock use. The Forest currently has two RNA's that exclude livestock, Shell Canyon and Bull Elk Park. These two areas would be excluded in all alternatives. Additional RNA's will be excluded in most of the alternatives, except the No Action alternative. Existing RNA's are available in the GIS library under the …/bighorn/admin directory in the "research_area" coverge.

4. Range Exclosures

Range exclosures (finite areas where no livestock grazing is allowed) exist throughout the Bighorn National Forest. Range Conservationists from each of the Ranger Districts provided a list of sites and maps where livestock grazing is excluded. These areas are documented in an ArcInfo coverage at: "J:/fsfiles/office/bhgis/infrarange/range_excl".

5. through 7. Primary roads, Secondary roads, and Railroads

The Desk Guide process describes two different road buffers for primary and secondary roads. The first buffer, used to describe capable rangelands, was supposed to identify only those areas that did not produce any forage. The second buffer, used to describe suitable rangelands, was supposed to identify forage that was not available due to right-of-way fences and other limitations. In practice, I used one buffer that included all of the non-capable and non-suitable lands. I found this necessary because of the intense computational load created by the buffer process. No additional acres will be shown as unsuitable based on this criteria. The coverage with buffers will be added back in after all of the other suitability screens have been processed.

8. Current grazing closures

There are several areas where livestock grazing is not scheduled at this time. In most cases this is the result of permit administration considerations, and not the result of any closure decision. No additional acres have been removed from the suitable grazing acres in this category.

9. Threatened, Endangered, and Sensitive Species Closures

No livestock grazing closures have been implemented for Threatened, Endangered, or Sensitive species.

10. Other incompatibilities

No additional acres have been removed for "other incompatibilities.

11. Economical Feasibility

Livestock use is limited in many areas due the effort required to get to a suitable water source. Some analysis has been done to define sites where livestock use is limited by the distance (both horizontal and vertical distance) to water. This analysis is not complete and may be used in the future to examine locations where the development of water sources may provide the greatest benefit. This data will not be used to limit available range acres at this time.

12. Final Suitable Range

The final step in this process does not describe any work, but only the result. In practice, I used this step to document the re-application of route buffers for Streams, Forest Service roads, and Highways.

In each of the process described above the coverage that is created is called "r-avail" with a number at the end of the name to represent the step in the process that has been processed. For example, "r-avail4" is the name of a coverage that has been processed for all of the steps up through step #4 listed above.

Economic Impact Analysis

Introduction

In order to estimate the economic effects to local communities, the area around the Bighorn NF was divided into east and west sections based on county boundaries. The east half includes Sheridan and Johnson counties, and the west is Big Horn and Washakie counties. The split was primarily based upon input from Dr. David "Tex" Taylor of the University of Wyoming Agricultural and Applied Economics Department. Dr. Taylor has had many years experience working with the economies of north central Wyoming, and explaining the implications of federal land management decisions to local residents. Dr. Taylor was the principal investigator for the draft revised forest plan economic analysis.

Procedures

The economic impacts of the Bighorn NF were analyzed using two input-output models. Modified IMPLAN databases were created for the east and west side economies. IMPLAN is a software package for personal computers that uses the latest national input-output tables from the Bureau of Economic Analysis, secondary economic data at the county level from a variety of sources, and proprietary procedures to develop an input-output model for a study area. The software was originally developed by the Forest Service and is now maintained by the Minnesota IMPLAN Group, Inc. (MIG).

The analysis considered three economic activities associated with the Bighorn NF including: 1) Recreation, 2) Timber Production, and 3) Livestock Grazing. Assumptions and base years for the different resource areas varied because of differing factors influencing outputs over the life of the existing plan. The basis for the base year selection is shown in Chapter 3 of the DEIS.

Data And Assumptions

Recreation

Future demand was determined by use of a "trends analysis" process. In other words, historic use data (e.g. past changes in the number of recreation visitor days) became predictors of future demand. Calculations were done for a 50-year period.

The visitation projections that were used for the economic analysis came from the Bighorn National Forest's Forest Recreation Use Database (FRUD). Description of how the projections were calculated are explained in detail in the "Recreation Analysis" section of this appendix.

For purposes of the economic analysis, FRUD forestwide recreation use projections for 2001 and 2010 were broken into east/west categories, as well as resident local (from within the four-county area of Sheridan, Big Horn, Washakie and Johnson Counties), resident nonlocal (Wyoming residents from outside of the four-county area), and nonresident categories. This estimation was necessary since economic impacts are based on new dollars flowing into the regional economy. Resident recreation expenditures, however,

represent a part of the current distribution of existing dollars already in the regional economy.

Determination of visitor origin information was primarily based on post-process analysis by Dr. Don English of the Bighorn 2002 National Forest's National Visitor Use Montitoring report. This origin information was used for all activities unless more activity-specific origin data was available. Examples of activities where more specific visitor origin information was available (compared to NVUM zip code statistics) include the following:

- Snowmobile permit sales information was used along with District staff observations to determine resident local/resident nonlocal/nonresident ratios.
- Origin ratios for hunting and fishing ratios were based on license information provided by Wyoming Game and Fish as well as conversations with Tom Rowe and Dick Johnson of Wyoming Game and Fish.
- Ski area origin ratios were based on a November 2003 conversation with Ermerson Scott of the Antelope Butte Ski Area.
- Dispersed camping origin information was based on observations made as part of the 1996 Clear/Crazy landscape analysis.
- Developed camping origin ratios were based on conversations with Gallatin County Campground concessionaire owner Esther Fischbaugh.
- Recreation residence origin ratios were derived from the Special Use Data System.
- Resort origin ratios were based on conversations with Bear Lodge and Meadowlark Lodge.

Visitation data for the year 2000 as well as estimated use projections for 2010 were then provided to the University of Wyoming for economic modeling purposes.

References

Bowker, J.M., D.B.K. English, and H.K. Cordell. 1999. *Projections of outdoor recreation participation to 2050*. USDA Forest Service. Athens, GA.

Kocis, Susan M, English, Donald B.K., Zarnoch, Stanley J., Arnold, Ross, and Warren, Larry. August 2002. *National Visitor Use Monitoring Results for the Bighorn National Forest.*

U.S. Fish and Wildlife Service, 1998, *1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation - Wyoming*, FHW/96-WY.

Wyoming Game and Fish Department, 1999, *Annual Report – 1999*, Cheyenne Wyoming.

Morey & Associates, Inc., 1999, *Report on the Economic Impact of the Travel Industry in Wyoming – 1998*, prepared for the Wyoming Business Council, Division of Tourism, Cheyenne, Wyoming.

Table B-9. Daily Per Person Recreation Visitor Expenditures

			Recreation
		Activity	Visitor
		Day	Day
Resident Fishing (1)		$27.42	N.A.
Nonresident Fishing (1)		$70.98	N.A.
Resident Elk (2)		$73.59	N.A.
Nonresident Elk (2)		$161.69	N.A.
Resident Deer (2)		$85.81	N.A.
Nonresident Deer (2)		$133.15	N.A.
Resident Sheep (2)		$199.18	N.A.
Nonresident Sheep (2)		$808.74	N.A.
Camping (3)		$34.26	$34.26
Day Trips (3)		$38.46	$57.69
Overnight Trips (3)		$57.72	$86.58

Sources:

U.S. Fish and Wildlife Service, 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, Wyoming (Adjusted to 1998 dollars).

Wyoming Game and Fish Department, Annual Report, 1999.

Morey & Associates, Inc., Report on the Economic Impact of the Travel Industry in Wyoming, 1998, Prepared for the Wyoming Business Council.

Table B-10. Timber Harvest (MBF) and Purchaser Location on the Bighorn NF, 1996-2002

Fiscal Year	Product (MBF)	Buffalo, WY	Sheridan, WY	Cody, WY	Livingston, MT
1996	POL				
1997	POL				
1998	POL				
1999	POL				
2000	POL	154			

Fiscal Year	Product (MBF)	Buffalo, WY	Sheridan, WY	Cody, WY	Livingston, MT
2001	POL	191			
2002	POL	45		66	
Total POL		**390**		**66**	
1996	Sawtimber		4533		
1997	Sawtimber		2474		
1998	Sawtimber		995	633	
1999	Sawtimber		845	60	660
2000	Sawtimber		300		1016
2001	Sawtimber	85	0	688	1084
2002	Sawtimber	143	0	178	35
Total		**228**	**9147**	**1559**	**2795**

Source: U.S. Forest Service, Bighorn National Forest

Table B-11. Value of Production for Wyoming Cattle and Sheep, 1989-98

	Per AUM Cattle	Per AUM Sheep
Year	(1997 $)	(1997 $)
1989	$34.95	$22.30
1990	$36.18	$16.65
1991	$45.02	$15.92
1992	$42.82	$20.77
1993	$44.28	$18.68
1994	$36.03	$21.39
1995	$31.32	$26.52
1996	$28.10	$25.52
1997	$31.80	$27.44
1998	$28.37	$20.86
Average	**$35.88**	**$21.60**

Source: Adapted from Wyoming Agricultural Statistics, Various Years.

Recreation Analysis

There were several processes conducted to analyze the issues associated with the recreation management topic. A summary of these processes follows.

Summer ROS Analysis

The recreation opportunity Spectrum (ROS) is a system for classification of outdoor recreation opportunity environments.

In preparation for this analysis, a baseline existing-condition summer ROS map for the Bighorn National Forest was compiled. The map for the existing ROS condition was built using USDA Forest Service, primary base series(PBS) maps built on 7.5 minute USGS quadrangles (1:24000). The original paper maps were drawn on canary tracing paper over PBS maps. Reference maps included: (1) a 1992 ROS map at ½"=1 mile; (2) the forest travel map at ½"=1mile; (3) the 1985 Forest Plan management area map; and (4) paper ortho-photo quadrangles at 1:24000.

ROS mapping is based on a process described in the USDA Forest Service publication, 1986 ROS Book. Most changes from the 1992 inventory of the existing recreation opportunities resulted from refinements based on the more detailed scale of mapping. Changes in the physical and managerial setting as a result of management activities between 1992 and 1998 were considered in mapping the ROS settings.

The summer ROS analysis involved comparing the adopted ROS for each management area by alternative as stated in the recreation guideline for each management area. Adopted ROS composition by alternative was determined by applying the existing Forestwide ROS map to each alternative map of management areas.

The adopted ROS class displays the maximum level of change that an area could experience in terms of ROS criteria over the life of the plan. It is likely that changes to the overall Forestwide ROS "mix" from the current ROS settings will be less extreme since the shift is based on the amount of management that takes place on the Forest. The utility of this analysis is strictly for purposes of alternative comparison.

The summer ROS analysis was mapped based on the following criteria:

MA	Summer ROS criteria
1.11	P
1.13	SPNM
1.2	If existing ROS = P, then P; otherwise ROS = SPNM
1.31	If existing ROS = P, then P; otherwise ROS = SPNM
1.32	If existing ROS = P, then P; otherwise ROS = SPNM
1.33	If within ½ mile of system summer motorized road or trail, then SPM. Otherwise, if existing ROS = P then P; If existing ROS = anything but P then SPNM.
1.5	P

MA	Summer ROS criteria
2.1	Based on current ROS.
2.2	If existing ROS = P then P; If existing ROS = anything but P then SPNM.
3.1	Based on current ROS.
3.24	No change from existing ROS (only found in alt A)
3.31	SPM
3.4	SPNM unless existing ROS = SPM, then it remains SPM
3.5	If existing ROS = SPNM then no change; otherwise ROS = SPM
4.2	If existing ROS = R then it remains R; otherwise RN
4.3	If existing ROS = P, SPNM or SPM then SPM; Otherwise it is RN.
4.4	RN
5.11	If existing ROS = P, SPNM, SPM or RM then it's RM; Otherwise it's RN.
5.12	If existing ROS = P, SPNM, SPM or RM then it's RM; Otherwise it's RN.
5.13	If existing ROS = P, SPNM, SPM or RM then it's RM; Otherwise it's RN.
5.21	No change from existing ROS (only found in alt A)
5.4	If existing ROS = P, SPNM, SPM or RM then it's RM; Otherwise it's RN.
5.41	If currently RN then no change. Otherwise SPM.
5.5	If existing ROS = P, SPNM, SPM or RM then it's RM; Otherwise it's RN.
8.1	RM
8.22	R

Description of abbreviations:

P	=	Primitive
SPNM	=	Semi-primitive nonmotorized
SPM	=	Semi-primitive motorized
RN	=	Roaded natural
RM	=	Roaded modified
R	=	Rural

Forestwide Demand Projections

Future demand was determined by use of a "trends analysis" process. In other words, historic use data (e.g. past changes in the number of recreation visitor days) became predictors of future demand. Calculations were done for a 50-year period.

This sort of analysis has drawbacks in that it fails to recognize the potential for "new" recreation activities (a good example of which was the all-terrain vehicle which became popular after the 1985 Plan was completed), it is unable to incorporate potential changes in national or local economics (increases in gasoline prices, etc), and it does not recognize changes in population demographics (e.g. aging Americans) which are instead addressed in the cumulative effects section.

The following steps summarize the "trends analysis" process used for the Plan Revision:

1. Recreation use figures (RVDs) were collected for various activities and displayed in table format for the years 1989 through 2000.
2. Data corrections were made for known errors, some specific examples:
    a. Camping RVDs were adjusted using data from two sources: (1)Developed camping from visitor numbers supplied by the campground concessionnaire, (2) Dispersed camping estimated from research done on what was formerly known as the Buffalo District during the summer of 1996.
    b. Auto travel RVDs were adjusted using State or Wyoming and Forest traffic count data.
    c. Big game hunting RVDs were adjusted using State of Wyoming "Hunter Day" data.
3. Activities were grouped according to two major categories. The first category represents activity groups needed for the IMPLAN economic model (subcategories include camping, dispersed non-motorized, dispersed motorized, big game hunting, small game hunting, nonconsumptive wildlife, fishing, downhill skiing, lodges/resorts/other). The second category combines activities into larger groups to give a more simple view of demand (subcategories include developed, dispersed, skiing, wilderness).
4. Average percent change per year for each activity and IMPLAN activity group was calculated.
5. The percent change growth factors were then used as multipliers and applied to historical use figures. To reflect expected national trends (changes in population demographics and economics) these factors were further refined using regional growth rates as determined by Bowker, et al, (1999). Adjustments were made using estimates of demand predicted by the US Forest Service for the years 2000 to 2055. These anticipated changes were incorporated mathematically into the growth factors for the time period predicted.

These calculations resulted in a spreadsheet which portrays likely future use projections out to the year 2055.

Effects to Dispersed Camping

Dispersed camping near developed campgrounds

The purpose of the particular effects analysis is to determine the extent of dispersed camping opportunities that will be effected as a result of the following guideline:

"Dispersed camping should not be allowed within ¼ mile of developed campground facilities unless otherwise designated."

The effect of this guideline does not vary by alternative.

While the Bighorn NF is in the process of compiling/assembling GIS data regarding a dispersed campsite inventory, the data layer is not yet complete enough to result in a GIS-based effects analysis which is accurate enough to determine whether or not a particular campsite will be effected by this guideline. While at some later date it might be possible to do a site-by-site GIS analysis, at present the only reasonable factor to use is Forest acres.

Another limitation based on GIS coverage also had to be accounted for. Developed campgrounds were represented by a point and not a polygon in the data layer. As a result, the buffered area (the area which is restricted to dispersed camping) may be very slightly smaller in size than if the GIS coverage included the actual size of the developed recreation site. This was a limitation that had to be worked with but one which should not result in a significant difference in acreage, only several percent, most likely. GIS Analysis determined that the buffered acreage around a single point amounted to 124.3 acres.

Private lands also had to be removed from the acreage base. In addition, existing special orders which prohibit or limit dispersed camping had to be accounted for in the baseline acreage before the actual effects analysis was conducted.

The resulting baseline acreage (before the ¼ mile guideline was applied) was 50,862 acres. To this basemap, the ¼ mile guideline was applied to obtain an acreage effect.

Lake/stream vicinity restriction on dispersed camping

The purpose of the particular effects analysis is to determine the extent of dispersed camping opportunities that will be effected as a result of this standard.

"Prohibit, or mitigate through other management practices, dispersed camping, within 100 feet (or OHWM) of lakes larger than ¼ acre and State listed water quality impaired streams and the mainstem of the 6th level municipal watersheds of Clear Creek, Goose Creek, Tensleep Creek, Shell Creek, and Tongue River."

As with the above analysis pertaining to campground facilities, it was necessary to determine how much acreage is already off-limits to dispersed camping prior to applying this particular standard. While the Bighorn NF is in the process of compiling/assembling GIS data regarding a dispersed campsite inventory, the data layer is not yet complete enough to result in a GIS-based effects analysis which is accurate enough to determine whether or not a particular campsite will be effected by this guideline. While at some later date it might be possible to do a site-by-site GIS analysis, at present the only reasonable factor to use is Forest acres.

The baseline acreage (acreage that is already off-limits to dispersed camping within 100 feet of the above-mentioned waterways) includes the entire Cloud Peak wilderness as a result of an existing special order, private lands, and areas currently under special orders with provisions that are relevant to this standard. The total baseline acreage amounted to 239,901 acres.

To this basemap, the waterway standard was applied to obtain an acreage effect.

Winter Recreation Opportunities

A winter recreation opportunities analysis was conducted which inventoried, by alternative, the amount of acreage open to over-snow motorized travel versus the amount of acreage that would offer a nonmotorized setting.

A baseline map was constructed showing both the Cloud Peak Wilderness as well as winter travel restrictions as a result of special order, travel map provisions (areas designated as "B areas" on the travel map are closed to snowmobile use) and mule deer and elk winter range areas as mapped by the State of Wyoming. Then, by alternative, management areas which effected motorized winter recreation opportunities were quantified. Existing designated Cloud Peak wilderness acres do not vary by alternative and as a result were used as part of the baseline existing condition across all alternatives to show the amount of acreage already closed to winter motorized recreation.

Current base acreage closed to motorized winter recreation amounted to 104,547 acres not including Cloud Peak Wilderness, which when added to the baseline acreage amounts to 296,441 acres, or almost 27% of the National Forest.

Outside of the Cloud Peak Wilderness, the following management areas have prohibitions on winter motorized recreation:

Management Area	Description
1.2	Recommended wilderness
1.31	Backcountry recreation non-motorized use
2.2	Research natural areas
5.41	Deer and Elk winter range

The above management areas were compiled by alternative and the net effect on winter motorized/nonmotorized acreage was determined using GIS.

Dispersed Motorized Recreation Effects

A major issue identified during pre-revision scoping activities was the need to restrict motorized travel to designated system routes. As a result, the following standard was adopted by the Forest Leadership Team:

"On all lands outside of designated travelways, motorized travel is prohibited unless the Forest Visitor Map or a Forest Order indicates such use is specifically allowed. Over snow vehicle use on snow is allowed unless specifically restricted."

The purpose of the particular effects analysis is to determine the extent of Bighorn National Forest acreage that will be effected as a result of this standard.

Using GIS-based methods, the number and size of existing C areas was determined. Total acreage of these existing C areas was calculated and percent of affected Forest acreage was calculated.

Roadless Inventory and Evaluation

Background

The Forest Service is required to inventory, evaluate and consider all roadless areas for possible inclusion in the National Wilderness Preservation System. 36 CFR 219.17 states:

"Unless otherwise provided by law, roadless areas within the National Forest System shall be evaluated and considered for recommendation as potential wilderness areas during the forest planning process…"

Historical Summary

In 1970, the Forest Service studied all administratively designated primitive areas, and inventoried and reviewed all roadless areas in the National Forest and Grasslands greater than 5,000 acres. This study was known as the Roadless Area Review and Evaluation (RARE). RARE was halted in 1972 due to legal challenge.

In 1977, the Forest Service began another nationwide Roadless Area Review and Evaluation (RARE II) to identify roadless and undeveloped areas within the National Forest System that were suitable for inclusion in the National Forest Wilderness Preservation System. RARE II was also challenged in court and it was determined that it did not fully comply with National Environmental Policy Act (NEPA) requirements. The Bighorn NF updated the RARE II analysis during the original Forest Plan analysis, publishing Draft EIS Appendix M in 1983.

Congress passed the Wyoming Wilderness Act of 1984 (PL 98-550) which designated one new wilderness areas on the Bighorn National Forest, the Cloud Peak Wilderness. The Wilderness boundary included the previously existing Cloud Peak Primitive Area, and portions of the Seven Brothers and Cloud Peak Contiguous roadless areas. The Wyoming Wilderness Act also released all remaining roadless areas to multiple use management (Title IV of the Wyoming Wilderness Act of 1984).

Laws, Policy and Direction

Initial authority for roadless inventories and evaluations is based on the Wilderness Act of 1964 (P.L. 88-577). Current direction for roadless area inventories and evaluations is found in 36 CFR 219.17. The primary intent of the evaluation is to consider areas for potential wilderness designation. Further requirements for evaluation of wilderness are found in FSH 1909.12,7, FSM 1923, and FSM 2320. FSH 1909.12,7 discusses the inventory criteria for roadless areas and their evaluation for wilderness. FSM 1923 is manual direction on wilderness evaluations as part of the forest plan revision process. FSM 2320 is manual direction on wilderness management. Based on the above direction, the region developed a guidance paper entitled *A Roadless and Unroaded Area Inventory,*

Purpose, Process and Products (R2 paper) prepared by the Region 2 Planning Analysis Team and Approved by the Regional Directors on 6/4/97 and revised 7/02.

Inventory Process

The first step in the evaluation of potential wilderness is to identify and inventory all roadless, undeveloped areas that satisfy the definition of wilderness found in section 2(c) of the 1964 Wilderness Act.

Section 2 (c) reads: "A wilderness, in contrast with those areas where man and his own works dominate the landscape, is herby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. An area of wilderness is further defined to mean in this Act an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) has outstanding opportunities for solitude or a primitive and unconfined type of recreation; (3) has at least five thousand acres of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value."

Using the process outlined in the R2 paper as a guide, the undeveloped areas of the forest were identified

- It contains 5,000 acres or more.
- It contains less than 5,000 acres.
    1. It is isolated and of sufficient size to be managed as wilderness.
    2. It is contiguous with an existing wilderness,
    3. It is contiguous with an area of other ownership with wilderness potential,
- It does not contain classified roads[2]

Areas of improvements with continuing maintenance requirements were generally excluded from the inventory. Map data used to eliminate these areas from the inventory included:

- Timber harvest units, pre-commercial and commercial thinning units
- Reservoirs
- Developed recreation and administrative sites

[2] Classified roads are wholly or partially within or adjacent to National Forest System lands that are determined to be needed for long-term motor vehicle access, including State roads, county roads, privately owned roads, National Forest System roads, and other roads authorized by the Forest Service (36 CFR 212.1. Unclassified roads including temporary roads were not excluded from the inventory. Classified roads were buffered by 300 feet.

- Electronic sites
- Utility corridors
- All of the lands that are not part of the National Forest System within the forest boundary.

However, some improvements were included in roadless areas. Examples include motorized trails, range fences, outfitter camps and historic harvest units where activities are no longer evident.

The maps were refined based on the following considerations.

- The definition of wilderness from section 2(c) of the 1964 Wilderness Act which states that areas should have outstanding opportunities for solitude and the imprint of man should be substantially unnoticeable
- The standards from the Recreation Opportunity Spectrum (ROS) for a semi-primitive non-motorized (SPNM) area that states a person should be ½ mile from a road to experience semi-primitive non-motorized opportunities
- The concept of ecological integrity, an area has to be large enough to provide for natural disturbance process without being influenced by the hand of man.
- The idea of practicability in a management sense.

The evaluation of the roadless areas for suitability as wilderness is discussed in Appendix C of the Draft Environmental Impact Statement.

Water Yield Analysis

This section describes the process used to analyze the probable changes in water yields as a result of vegetation management proposed in the Bighorn National Forest. This analysis was completed to address the issue of whether and how much water yield could be expected as a result of forest management activities. The protocols utilized to estimate water yield changes are all similar for the Arapaho and Roosevelt, Routt, Medicine Bow, and Bighorn Forest Plan revisions.

Water from the Forest is used not only for municipal and agricultural uses but also for instream uses. Streamflow from forested watersheds is primarily a function of total precipitation and losses due to evapotranspiration and groundwater storage. Trees in the watershed affect streamflow by transpiring water, intercepting snow or rain which may be evaporated or sublimated back into the atmosphere, and by modifying the understory's evapotranspiration (Kaufmann et al. 1987). Reductions in forest canopy density results in water being available for streamflow by reducing evapotranspiration and increasing snowpack accumulation into the openings (Alexander et al. 1985). Many experiments have measured changes in streamflow from reductions in vegetative cover on small watersheds, less than a couple square miles (e.g. Bosch and Hewlett,1982). Research on the 6.5 square mile Coon Creek watershed in the Sierra Madre range did not show a

significant increase in streamflow until after timber was harvested on 24 percent of the watershed (1.56 square miles or 998 acres) (Troendle et al. 1998).

Precipitation is a primary factor influencing water yield from a basin and the change in water yield caused by vegetation management is also largely determined by the amount of precipitation which occurs on a site. Thus, treatment in spruce-fir yields the greatest change per unit area, because spruce-fir typically occupy the wetter sites. Changes are smaller for treatment of lodgepole pine and smallest for ponderosa pine. Changes in streamflow from vegetation management are not permanent. As an area is restocked and the trees grow, water that was available for streamflow is slowly redirected back to evapotranspiration. Research at the Fraser Experimental Forest indicates that changes in water yield from timber harvest persist at declining levels for approximately 80 years (Troendle and King, 1985).

Information from the Analysis of the Management Situation report (USDA, 1981) shows a baseline water yield of 693,363 acre-feet, for the entire Forest and an existing water yield estimated at 701,286 acre-feet, based on equivalent clearcut area and acres of road. These water yield values were obtained using the HYSED analysis (Silvey and Rosgen, 1980). It is not likely that the alternatives analyzed in detail in this Forest Plan Revision would result in detectable increases in water yields at the Forest scale. The basis for this determination comes from the limited amount of timber harvesting that is being proposed in the action alternatives as compared to that necessary to produce detectable increases in water yield and is supported by modeling on other forests with similar climatic and vegetative conditions.

1. Changes in water yield as a result of alternative vegetation management scenarios were estimated for the Medicine Bow Forest Plan Revision (Chambers 2002). Timber harvest, fuels treatment (prescribed fire and mechanical treatment), wildfire and insect and disease were all analyzed by alternative for changes in water yield. After an exhaustive water yield analysis, they concluded; "*Thus, there would be no significant, measurable local or regional change in water yield from any of the Forest Plan alternatives*."

2. The Medicine Bow National Forest showed average water yield increases in the first decade of Plan implementation from all types of vegetation management. However, total water yield increases did not vary significantly by alternative, presumably as a result of similar reductions in forest canopy cover for all alternatives. The mechanism by which the density of forest cover changes does vary by alternative as management prescriptions tend to emphasize one type of vegetation management over others. The changes in the type of vegetation management tend to compensate for each other in terms of water yield increase. In other words, an alternative with a greater amount of timber harvest tends to have less wildfire, and an alternative with more wildfire tends to have less timber harvest.

   The differences in water yield between alternatives as a result of vegetation management are greatly masked by the comparison to other water quantity values

on and downstream of the Forest. The modeled water yield increases that might be generated by any of the alternatives as a result of vegetation management are quite small when compared to the natural average annual water yield at the local watershed (<2%), Forest (<0.2%) and basin-wide scale (<0.1). While real, these projected increased yields are a very small component of the water produced on the Forest, and the difference in water yield between alternatives is even less significant.

Research from small watersheds shows that approximately 20 – 25 % of the forest cover must be removed to show a measurable on-site increase in water yield. These increased yields are not dependent on a particular silvicultural prescription. Although most water yield studies have been done on small watersheds (e.g. 714 acre Fool Creek on the Fraser Experimental Forest), the Coon Creek experiment on the Medicine Bow National Forest demonstrated that water yields were also shown to increase on this 4,133 acre drainage when it was impacted to the same degree (24 % of the watershed was impacted by road construction or timber harvest) (Troendle at al, 1998). It is reasonable to conclude that these results can be extrapolated to larger watersheds, as long as the entire forested landscape in the watershed is impacted to the same degree.

3. Therefore, to realize measurable increases in water yield from vegetative manipulation on the Bighorn National Forest, approximately 25 % of the forested landscape in the Powder River Basin or the Bighorn River Basin would have to be removed at a given time. The Powder River Basin on the Forest contains 194,264 acres of forested landscape – 25 % of these acres equals 48,566 acres. Recent history shows that only 550 acres of final timber harvest has occurred per year for the last 17 years since the last forest plan revision (2002 Bighorn National Forest Monitoring Report). These acreages are significantly less than those needed to have a measurable effect on water yield at the river basin scale. Large-scale natural events, such as fire, insects, disease or blowdown, may have the potential to reduce forest cover on enough acreage at one time to result in measurable changes in water yield at the Forest or river basin scale. Based on recent history, events of this size are rare on the Forest.

4. Most discussions of potential water yield increases are presented as averages. These average numbers do not represent the actual variability on a monthly or annual basis. Research shows that water yield increases for subalpine landscapes in the Rocky Mountains are limited to the months of spring runoff (typically May or June) and are not present in any other month of the year (Troendle and Nankervis, 2000). Additionally, increases are proportional to the natural precipitation in the basin – i.e. a percentage increase in a flow in a wet year will be a greater absolute increase than a percentage increase in a dry year. A drought will still be a drought, and a flood will be a bigger flood. Rare, large flow events may distort "average" numbers by making them appear higher, but in reality these events are seldom captured or put to beneficial use. The most reliable indicator for water yield from large basins is precipitation, which is fairly constant in the long term. Researchers

have not been successful in finding other significant correlations at this scale (Kircher et. al. (1985) discussed in Troendle and Nankervis, 2000).

5. Modeled water yield increases are generally difficult to measure off-site because they are an extremely small fraction of total streamflow. Where water yield increases have been measured on-site, they are undetected in the next larger watershed. The inability to measure these increases off-site, or to measure transmission losses to the point of use, makes it virtually impossible to document the magnitude or persistence of modeled increases in water yields as they are transmitted downstream. Therefore, although we can use models such as WRENNS to estimate theoretical on-site increases in water yield from timber harvest across larger forested landscapes, we cannot track or measure these theoretical increases at the larger scales.
6. Extrapolating the results from small watershed studies to larger basins can easily result in overstated goals and benefits. The realities of fixed and variable constraints such as land ownership, inoperable lands that are too steep, unstable or unproductive, multiple use coordination, water quality or habitat concerns are often left out of analyses that make broad conclusions about possible water yield increases across large landscapes. These practical limitations and resource coordination requirements limit our ability to remove the forest cover from a large portion of the landscape. At Coon Creek, which was set up as a water yield research study, the intent was to harvest one third of the watershed, but other considerations resulted in only 24 percent of the watershed actually being harvested (Troendle and Nankervis, 2000).

   As discussed above water yields that are realized are proportional to precipitation. The largest increases would be predicted to occur in wet years when reservoir storage is least available to capture increased flows.

   Maintenance of the increased water yield over time presents an additional operational constraint. Water yield persists over time following vegetation manipulation at a decreasing rate as vegetation grows back to pre-treatment conditions. To continue to realize the increase in water yield, vegetation within the watershed would have to remain in the altered condition. Short of vegetation type conversion, this would require near perpetual manipulation of vegetation over large areas, a near impossible task given the operational constraints noted above.

   In the first round of forest planning, Forests had the option to emphasize water yield increases through a specific management area prescription. For Forest Plan Revisions, the Region has elected not to use a specific management area prescription for water yield emphasis in light of the scientific and operational constraints discussed above and experience in implementing current Forest Plans. Regional policy is that modeled water yield increases will be a result of normal timber management and fuels reduction prescriptions rather than an output of forest management.

7. Technical, social, political, operational and legal constraints of increasing water yields through forest management have been well documented (e.g. Troendle and Nankervis, 2000; Ziemer, 1987; Ponce and Meiman, 1983). Most beneficial uses of water, such as fish-bearing streams or diversions for agriculture, occur at locations where water yield changes due to vegetation management on the Forest are unlikely to be measureable. While real, these increased yields do not contribute significantly to beneficial uses at the local level or to enhanced wildlife habitat in downstream habitats.

Based on the above discussion, it is unlikely that there will be any detectable increase in water yields as a result of the proposed alternatives.

Biological Diversity Analysis

Forest Vegetation Simulator The primary tool used for estimating growth of forest stands was the Forest Vegetation Simulator (FVS) {Wycoff 1986, Wycoff *et al.* 1990, Teck 1996}. FVS is an individual-tree, distance-independent, growth and yield model. It has its structural roots in the Stand Prognosis Model developed by Albert Stage from the Intermountain Research Station {Stage 1973}. Staff at the USFS Forest Management Service Center in Fort Collins have now calibrated a variant of this model for the Central Rockies geographic area {Dixon 2001}. FVS extensions were also used to allow modeling of canopy cover {Crookston and Stage 1999, Crookston 1985, 1990}.

The results of FVS modeling were incorporated into:

- Growth and yield information for inclusion in the *Woodstock*© modeling of timber harvest;
- Determining residence times for structural stages for successional stage modeling.
- Determining fire regime and condition class, and crown bulk density, used to calculate fire risk and hazard.

FVS allows the user to calculate estimates of forest stand structure and species composition over time and quantify this information to (1) describe current and future forest stand conditions, (2) simplify complex concepts of forest vegetation into user-defined indices, attributes, etc., and (3) allow the manager to ask better questions about growth and yield of forested stands and complete analyses to answer those questions.

The FVS model structure contains modules for growing trees; predicting mortality; establishing regeneration; simulating growth reductions, damage, and mortality due to insects and disease; performing management activities; calculating tree volumes; and producing reports. One of the strengths of the FVS system is its ability to incorporate local growth rate data directly into the simulation results.

FVS information for *Woodstock*© used actual forest stand data selected from the Forest's IRI database to project growth and yields for future outputs. FVS information for other

applications modeling regeneration from bare ground using average forest parameters (elevation, aspect, stocking, species representation) by cover type.

Forest Successional Stage Modeling Structural stages are used for a variety of forested land analysis. FVS modeling was used for structural stage development in the lodgepole, spruce/fir and Douglas fir cover types. Because there were no FVS runs for non-commercial species, to model the successional path of these cover types the Forest used a local successional stage development model created for the 1994 ASQ analysis. For these cover types, vegetation development followed a pathway based upon basic successional processes. Natural disturbances included wildland fire; insect and disease events were not included because of the random, stochastic nature of these events.